**Critical Thinking in *Star Trek***

**By**

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**DRAFT!!!**

Given that I am a “Trekkie,” I find that scenes from Star Trek frequently come to mind as I teach various philosophy courses. Over the years, I’ve collected a number of scenes that illustrate a number of commonly taught logical principles. I will assume that the reader has a general familiarity with the original series and with the Next Generation characters. In what follows, I will describe the episode in enough detail that the reader will be able to make sense of the scene. Rather than paraphrasing the relevant scenes, I will provide a transcription of the entire scene so that the reader can think through the scene on their own.

The first few scenes will highlight instances of conditional reasoning. In particular: *modus ponens, modus tollens*, and the fallacies: affirming the consequent and denying the antecedent. Subsequent scenes will illustrate arguments by analogy and instances of Mill’s methods.

**I. Conditional Reasoning**

**Most Toys – Star Trek: The Next Generation**

In this episode, Lt. Commander Data, an android, has been kidnapped by Kevis Fazio, who is a collector of rare objects. He has taken Data because he is unique—there is nothing else like him in the universe. Fazio has designated a chair where he expects Data to sit on display. He also expects Data to entertain Fazio’s friends when they come to parties. Earlier in the episode, a woman named Varria conspires with Data to escape from this captivity, but Fazio discovers their plan and kills Varria with a weapon called a “disrupter.” In the aftermath of this murder, Data picks up this weapon and confronts Fazio with it. Earlier in the episode, told Fazio that his programming includes routines that insure that he will always show a fundamental respect for all living beings. This is similar to Asimov’s “[Three Laws of Robotics](http://en.wikipedia.org/wiki/Three_laws)” that you might be familiar with from the movie, “I, Robot.” Given this knowledge, Fazio believes that Data is bluffing.

Fazio: You won't hurt me. Fundamental respect for all living beings. That's what you said. I'm a living being. Therefore, you can't harm me.

Data: You will surrender yourself to the authorities.

Fazio: Or what? You'll fire? Empty threat and we both know it. Why don't you accept your fate? You'll return to your chair and you will sit there. You will entertain me and you will entertain my guests. And if you don't, I'll simply kill someone else, him perhaps. It doesn't matter, their blood will be on your hands too just like poor Varria's. Your only alternative, Data, is to fire. MURDER me! That's all you have to do. Go ahead. Fire!

 If only you could feel rage over Varria's death. If only you could feel the need for revenge, then maybe you could fire. But you're just an android. You can't feel anything can you? It's just another interesting intellectual puzzle for you . . . another of life's curiosities.

Data: I can not permit this to continue.

Fazio: Wait. Your program won't allow you to fire. You can't fire. No!

Fazio offers the following argument, which exemplifies the *modus ponens* form:

(1) If Fazio is a living being, then Data cannot harm Fazio. [this is a paraphrase of Data's limiting subroutine].

(2) Fazio is a living being.

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(3) Data cannot harm Fazio.

He also offers the following argument, which exemplifies the *modus tollens* form:

(1) If you do not return to your chair and entertain me and my guests, then you may bring it about that I kill someone else.

(2) You can not bring it about that I kill someone else. [paraphrase of Data's limiting subroutine].

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(3) Therefore, you must return to your chair and entertain me and my guests.

Fazio is betting his life on his belief that Data’s programming will not allow him to kill a human being. He assumes that this prohibition is absolute and cannot be out weighed by other considerations. For example, he assumes that Data is not a utilitarian who might calculate that the greater good would involve the suspension of the generally valid rule that humans are not to be harmed. In the next sentence, we see that Fazio also makes presumptions about Data’s emotional capacities. He implicitly relies on an argument something like the following, the first part of which is another example of *modus ponens*:

(1) If you are an android, then you lack the capacity to feel or react in accordance with emotions. (general knowledge; definition of “android”)

(2) Data is an android.

(3) Therefore, Data lacks the capacity to feel or react in accordance with emotions.

(4) Revenge is an emotion.

(5) Therefore, Data lacks the capacity to feel or react in accordance with revenge.

Based on this implicit argument, Fazio then offers the following argument, which commits the fallacy of denying the antecedent:

(1) If you could feel the need for revenge, then you could fire the disrupter.

(2) You can not feel the need for revenge. [conclusion of the previous argument].

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(3) Therefore, you can not fire the disrupter.

This fallacy almost costs Fazio his life. Just after the last sentence, Data is beamed off of Fazio’s ship by the crew of the Enterprise. During the transport process, they discover that Data is holding a weapon that has discharged. The moral of this scene might be: When you are gambling with your life, you should avoid logical fallacies.

**Specter of the Gun – Star Trek: The Original Series**

In this episode, Kirk, Spock, and McCoy have been transported to a planet where they are being held in an artificial environment that is inexorably leading to a reenactment of the gunfight at the OK corral. Unfortunately, they are playing the role of the men who die during that gunfight. If they continue on their present path, it will surely lead to their death. Although, they appear to be in an artificially constructed scene, they believe that the danger is real, because earlier in the episode, Mr. Chekhov was killed. In their effort to avoid their fate, they try to find a way to avoid making it to the gunfight scene. When they discover some chemicals, they decide to concoct a tranquilizer. The thought is that they can knock themselves out at the appropriate time and thereby avoid the deadly gunfight. The device has been constructed and Scotty volunteers to be the test subject. He breaths in the gas and nothing happens.

Kirk: It doesn't work!

Spock: Indeed! Fascinating.

Kirk: It was our last chance.

Spock: Captain, you don't seem to understand. It did not function, but it must function.

McCoy: Nothing could go wrong, Captain. It should work.

Spock: A scientific fact. But if the tranquilizer does not function, which is clearly impossible, then a radical alteration of our thought patterns must be in order.

Kirk: We need a weapon, an answer.

 [later in the episode. . . ]

Spock: Physical laws simply cannot be ignored. Existence cannot be without them.

McCoy: What do you mean, Spock?

Spock: I mean, Doctor, that we are faced with a staggering contradiction. The tranquilizer you created should have been effective.

Kirk: It would have been effective anywhere else.

Spock: Doctor, in your opinion, what killed Mr. Chekhov?

McCoy: A piece of lead in his body.

Spock: Wrong. His mind killed him.

McCoy: Well come on, Spock, if you've got the answer then tell us.

Spock: Physical reality is consistent with natural laws. Where those laws do not operate there is no reality. All of this is unreal.

McCoy: What do you mean "unreal"? I examined Chekhov. He's dead!

Spock: But you made your examination under conditions that we cannot trust. We judge reality by the responses of our senses. Once we are convinced of the reality of a given situation, we abide by its rules. We judge the bullets to be solid, the guns real, therefore they can kill.

Kirk: Chekhov is dead because he believed the bullets would kill him.

Spock: He may indeed be dead. We do not know.

Kirk: But we do know that the Malcosians created this situation. If we do not allow ourselves to believe the bullets are real, they cannot kill us.

Spock: Exactly, I know the bullets are unreal. Therefore, they cannot harm me.

In logic, we typically hold the laws of nature to be constant. Indeed, it is a pre-condition for our notion of validity. If we can’t rely on the constancy of the laws of nature, then every argument would be subject to radical ambiguities. Our ordinary logical reasoning requires that words maintain the same meaning throughout the argument and that the laws of nature stay the same. In this circumstance, Spock realizes that these assumptions may not be true. So, he adjusts his reasoning to accommodate that possibility. Strange situations require strange arguments. Thus, although you and I would never bother to reason about the law of nature, under these highly unusual circumstances, we find Spock offering the following *modus tollens* argument:

(1) If the laws of nature are valid in this place, then the tranquilizer must work.

(2) The tranquilizer does not work.

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(3) Therefore, the laws of nature are not valid in this place.

Then, using *modus ponens*, Spock argues:

(4)If the laws of nature do not hold true here, then a radical alteration of our thought patterns must be in order.

(5)The laws of nature do not hold true here. [from previous argument]

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(6)Therefore, a radical alteration of our thought patterns is in order.

Paraphrasing just a bit, Spock then offers the following *modus tollens* argument:

(7) If a situation is real, then physical laws hold true in that situation.

(8) Physical laws do not hold true in this situation.

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(9)Therefore, this situation is not real.

The conclusion that the physical objects in this current situation are not real is just the insight that Spock needs to combat the threat of the gunfight. On the other hand, this conclusion is counter balanced by Mr. Chekhov’s death. In an effort to reconcile these two points, they reason in a manner something like the following:

(9) Everything in this world is unreal.

(10) Therefore, the bullet shot at Mr. Chekov was unreal.

(11) An unreal bullet cannot do real damage.

(12) If Mr. Chekov is dead, then he was killed by something unreal.

(13) Something that is unreal can harm you only if you believe it is real.

If we transpose this final claim, we get:

(14) If we do not believe the bullets are real, then they cannot kill us.

This conclusion provides them with what they need to survive the gun fight scene. Spock uses the Vulcan mind-meld technique to firmly implant into each of their minds the belief that the bullets are unreal. Therefore, when they get shot with these unreal bullets, they are unharmed. From a logical point of view, Spock and Kirk jointly offering the following *modus ponens* argument:

(14) If we do not believe the bullets are real, then they cannot kill us.

(15) We do not believe the bullets to be real. [Spock guarantees this by using the Vulcan mind-meld technique]

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(16) Therefore, the bullets cannot harm us.

Mr. Chekhov is dead (if he is dead) only because he believed that the bullets were real. It is worth noticing that their survival depended upon Mr. Spock’s ability to reframe the issue and thereby to discover an alternative strategy to solving their problem.

**II. Arguments by Analogy**

**Who Watches the Watchers**? **– Star Trek: The Next Generation**

In this episode, the Enterprise is visiting a planet that is inhabited by people who have a vastly more primitive culture and technology. While studying these people, Federation anthropologists are discovered and this leads to an interference with the development of this culture. Through an odd series of mistakes, Nuria, the leader of these people, comes to believe that Captain Picard is a god. This is diametrically opposed to their general naturalistic and secular tendencies of this culture. Picard decides to talk with Nuria in the hope that he can persuade her that he is not divine. Nuria is beamed aboard the Enterprise, and Picard leads her on a tour of the ship. Then they have the following exchange:

Nuria: Your powers are truly boundless.

Picard: Nuria, your people live in huts. Was it always so?

Nuria: No. We have found remnants of tools in caves. Our ancestors must have lived there.

Picard: So why do you now live in huts?

Nuria: Huts are better. Caves are dark and wet.

Picard: So if huts are better, why did you once live in caves?

Nuria: The most reasonable explanation would be that at one time we did not know how to make huts.

Picard: Just as at one time you did not know how to weave cloth, how to make a bow.

Nuria: That would be reasonable.

Picard: Someone invented a hut. Someone invented a bow. Who taught others, who taught their children, who built a stronger hut, who built a better bow, who taught their children. Now, Nuria, suppose one of your cave-dwelling ancestors were to see you as you are today. What would she think?

Nuria: I don't know.

Picard: Well, put yourself in her place. You see, she cannot kill a hornbuck at a great distance. You can. You have a power she lacks.

Nuria: Only because I have a bow.

Picard: She has never seen a bow. It doesn't exist in her world. To you its a simple tool. To her, its magic.

Nuria: I suppose she might think so.

Picard: Now, how would she react to you?

Nuria: I think she would fear me.

Picard: Just as you fear me.

Nuria: I do not fear you any longer.

Picard: Good. That's good. You see . . . my people once lived in caves and we then learned to build huts and in time to build ships like this one.

Nuria: Perhaps one day my people will travel above the sky.

 Picard: Of that I have absolutely no doubt.

In this discussion, Picard offers the following argument by analogy:

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| Things being compared | Properties shared in common |
| Picard, Nuria | (a) they are perceived to by more primitive people to be gods, (b) they have powers that others lack and cannot understand; and, (c) they are feared by those who do not understand their powers. |
| Nuria | is not a god. |
| Therefore, it is likely that Picard  | is not a god. |

**The Measure of the Man – Star Trek: The Next Generation**

Commander Maddox, a cyberneticist, has proposed dismantling Lt. Commander Data so that he can study him and make others like him. If this is done, the prospects for Data are dim and he does not wish to submit to the process. To avoid this end, Data has submitted a letter of resignation to Starfleet. Captain Picard goes to a meeting to defend Data's decision.

Cmd. Maddox: You're response is emotional and irrational.

Capt. Picard: Irrational?

Cmd. Maddox: You are endowing Data with human characteristics because it looks human. But it is not. If it were a box on wheels, I would not be facing this opposition.

[later in the scene . . .]

Cmd. Maddox: Data must not be permitted to resign.

Capt. Picard: Data is a Starfleet officer. He still has certain rights.

[later in the scene . . .]

Cmd. Maddox: Data is an extraordinary piece of engineering, but it IS a machine. . . . Starfleet does not have to allow the resignation.

[later in the scene . . .]

Cmd. Maddox: Let me put it another way. Would you permit the computer of the Enterprise to refuse a refit?

Capt. Louvois: That's an interesting point. But the Enterprise computer is property. Is Data?

Cmd. Maddox: Of course.

[later in the episode, after the prosecution's presentation.]

Capt. Picard: Commander Riker has dramatically demonstrated to this court that Lieutenant Commander Data is a machine. Do we deny that? No! As it is not relevant. We too are machines. Just machines of a different type. Commander Riker has also reminded us that Lt. Commander Data was created by a human. Do we deny that? No! Again, it is not relevant. Children are created from the building blocks of their parent's DNA. Are they property?

[later in the scene . . .]

Capt. Picard: Commander, is your contention that Lt. commander Data is not a sentient being and therefore not entitled to all of the rights reserved for all life forms within this federation?

Cmd. Maddox: Data is not sentient. No.

Capt. Picard: Commander, would you enlighten us? What is required for sentience?

Cmd. Maddox: Intelligence, self-awareness, consciousness.

[later in the scene . . .]

Capt. Picard: Is Lt. Commander Data intelligent?

Cmd. Maddox: Yes! It has the ability to learn and understand and to cope with new situations.

Capt. Picard: Like this hearing.

Cmd. Maddox: Yes.

Capt. Picard: What about self-awareness? What does that mean? Why am I self-aware?

Cmd. Maddox: Because you are consciousness of your existence and actions. You are aware of yourself and your own ego.

Capt. Picard: Commander Data, what are you doing now?

Data: I am taking part in a legal hearing to determine my rights and status. Am I a person or property?

Capt. Picard: And what's at stake?

Data: My right to choose. Perhaps my very life.

Capt. Picard: My rights. My status. My right to choose. My life. Well, it seems reasonably self-aware to me, commander. . . . I'm waiting.

[later in the scene . . .]

Capt. Picard: What is Data?

Cmd. Maddox: I don't understand.

Capt. Picard: WHAT IS HE?!!!

Cmd. Maddox: A machine!!

Capt. Picard: Is he? Are you sure?

Cmd. Maddox: Yes!!

Capt. Picard: You see he has met two of your three criteria for sentience. So what if he meets the third--consciousness--in even the smallest degree? What is he then? I don't know. Do you? Do you?

[later in the episode . . .]

Capt. Louvois: Is Data a machine? Yes. Is he the property of Star Fleet? No. . . . It is the ruling of this court that Lt. Commander Data has the right to choose.

Commander Maddox's initial charge of anthropomorphism emerges because he understands Picard to be offering something like the following analogical argument:

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| --- | --- |
| Things being compared | Properties shared in common |
| Humans, Data  | look alike and act similarly |
| humans | have rights |
| Therefore, it is likely that Data | has rights. |

Commander Riker's prosecution case rests on the following analogical argument:

|  |  |
| --- | --- |
| Things being compared | Properties shared in common |
| The Enterprise computer, all other computers, Data | (a) contain software written by a human, (b) are made of hardware designed and engineered by a human, (c) they can be shut off by a human, and (d) they are constructed so as to serve the aims of humans |
| the Enterprise computer, all other computers | lack the right of self-determination |
| Therefore, it is likely that Data  | lacks the right of self-determination |

Picard argues that there is a disanalogy between Data and other computers/machines. Specifically, he maintains that Data is sentient whereas other computers/machines are not.

He offers the offering the following analogical argument:

|  |  |
| --- | --- |
| Things being compared | Properties shared in common |
| Any other Starfleet officer, many other beings in the Federation, Data | intelligence, self-awareness, and consciousness |
| Other Starfleet officers, and many other beings in the Federation | have the right of self-determination |
| Therefore, it is likely that Data  | has the right of self-determination |

Picard's argument can also be expressed in the following form:

(1) If a being is intelligent, self-aware, and conscious, then it is sentient.

(2) Data is intelligent and self-aware.

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(3) Therefore, if Data is conscious, then he is sentient.

(4) Whether a being is conscious or not is epistemically indeterminate.

(5) If we face an epistemically indeterminate question about consciousness, we should err on the side of caution and presume that beings are conscious until we have good grounds for believing otherwise.

(6) We have no grounds for believing that Data is not conscious.

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(7) Therefore, we should presume that Data is conscious.

From (3) and (7) we get:

(8) We should presume that Data is sentient.

Given the additional assumption that:

(9) If a being is sentient, then it has the right of self-determination.

From (8) and (9) we can conclude:

(10) We should presume that Data has the right of self-determination.

**III. Mill’s Methods**

**Cloudminders – Star Trek: The Original Series**

In this episode, Kirk, McCoy, and Spock are visiting Stratos, a city in the clouds above the planet Ardan. The citizens of the cloud city enjoy a privileged life, while the Troglites, those who inhabit the planet below, are treated as inferior slaves. A few of the Troglites are chosen to be servants to the Stratos-dwellers. This role allows some Troglites to live in the cloud city. The disparity of wealth and the oppression has led several of these servants to become "disruptors”—a kind of insurgency group. Vanna is the leader of the disruptors. In the following scene, the main characters are discussing what might have caused this situation.

McCoy: Medical analysis indicates that the Troglites are mentally inferior.

Kirk: That's impossible. The Troglites have accepted personal sacrifice, a common cause--mentally inferior beings are incapable of that.

McCoy: Look, I've checked my finding thoroughly. Their intellect ratings are almost 20% below average.

Spock: But they are all of the same species. Those who live on Stratos and those who live below all originated on the planet. Their physical and mental evolution must be similar. That's basic biological law.

McCoy: That's true, Spock. But obviously the ancestors of those who live on Stratos removed themselves from the environment of the mines. Therefore, they avoided the effects of certain natural growths.

Kirk: Natural growths? What kind?

McCoy: Well, I had this zenite sample sent up from the surface. Now unsealed, it would have had the detrimental effects on everybody here.

Spock: Incredible!! Zenite is shipped all over the galaxy. Wherever there is danger of plant bacteria. No side effects have been reported.

McCoy: There are none, *after* it has been refined. But in its raw state it emits an odorless invisible gas that retards the intellectual function of the mind and heightens the emotion. Therefore it releases a violent reaction.

Kirk: And the mines are full of that gas.

McCoy: That's right, and the Troglites are constantly exposed to it.

Kirk: Bones--the disruptors, Vanna--it seems impossible. They have out-witted a highly organized scientific culture for months.

Spock: As part of the staff of Stratos, Vanna has removed from exposure for a long period. It is likely that without such exposure, the effect slowly wears off.

McCoy: That's right, Spock. And the other disrupters were probably removed from the exposure too.

Kirk: Does the brain return to normal?

McCoy: According to findings, it should.

Kirk: Can you neutralize the gas?

McCoy: No. But a filter mask should remove the exposure.

Initial facts to be explained:

(1) Ardanans have been split into two mainly isolated groups: Troglytes and Stratos-dwellers

(2) The Troglytes mine zenite on the planet.

(3) The Troglytes are violent and tests show that they are mentally inferior.

(4) Some of the Troglytes have out-witted a highly developed scientific culture for months. They have worked toward a common end and exhibited self-sacrifice.

The initial facts appear to be in tension. Kirk challenges (3) with a modus tollens argument.

If you are a mentally inferior being, then you can not accept personal sacrifice nor work in a common cause.

The Troglytes have accepted personal sacrifice and worked in a common cause.

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Therefore, the Troglytes are NOT mentally inferior.

Spock challenges (3) with a pair of modus ponens arguments.

If you are members of the same species and have the same origins, then your physical and mental evolution must be similar.

The Troglytes and Stratos-dwellers are of the same species and they have the same origin.

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Therefore, the physical and mental evolution of the two groups must be similar.

If the physical and mental evolution of two groups is similar, then one group will not be mentally inferior to another.

The physical and mental evolution of two groups is similar.

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Therefore, the Troglytes are not mentally inferior to the Stratos-dwellers.

Dr. McCoy uses Mill's method of difference to suggest that it is the zenite in the mines that causes the divergence in mental ability.

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| --- | --- |
| factors | effects |
| Troglytes | species x | origin y | exposed to zenite | mental inferiority |
| Stratos-dwellers | species x | origin y | no exposure to zenite | not mentallyinferior |
| Therefore, exposure to zenite cause mental inferiority |

This point can also be made with the following modus ponens argument.

If you are exposed to zenite, then you suffer detrimental effects.

The Troglytes are often exposed to zenite.

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Therefore, the Troglytes suffer detrimental effects.

Spock then adds to our initial list of facts:

(5) Zenite has never been reported to have any negative effects.

Using this new fact, Spock challenges McCoy's hypothesis with a modus tollens argument.

If zenite were dangerous, then we would have had many reports about its bad effects.

We have not had many reports about the bad effects of zenite.

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Therefore, zenite is not dangerous.

McCoy makes another distinction, using Mill's method of difference.

|  |  |
| --- | --- |
| factors | effects |
| Troglytes | Raw zenite | Violent behavior |
| Many others | Refined zenite | No violent behavior |
| Many others | Refined zenite | No violent behavior |
| Therefore, exposure to raw zenite causes the violent reaction. |

Kirk presses a remaining concern with the following modus tollens argument.

If the Troglytes were mentally inferior, then they would not be able to out-wit a highly organized scientific culture for months.

The Troglytes have out-witted a highly organized scientific culture for months.

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Therefore, the Troglytes are not mentally inferior.

Spock uses Mill's method of difference to distinguish between two groups of Troglytes--miners and disrupters.

|  |  |
| --- | --- |
| factors | effects |
| Troglytes | Miners | exposure to raw zenite | Violence; no self-sacrifice; incapable of working in common cause  |
| Disrupters | work on Stratos | no exposure to raw zenite | No violence; self-sacrifice; capable of working in common cause; can out-witting an advanced culture |
| Vanna | work on Stratos | no exposure to raw zenite | No violence; self-sacrifice; capable of working in common cause; can out-witting an advanced culture |
| Therefore, removal from exposure to raw zenite cause the Disrupters and Vanna to be able to engage in self-sacrifice, be capable of working in common cause, be capable of out-witting an advanced culture. |

Finally, McCoy and Spock conclude with the following modus ponens argument.

If you removed your exposure to raw zenite, then your mental faculties return to normal.

Vanna and the other Disrupters were removed from exposed to zenite.

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Therefore, their mental faculties returned to normal. That is, the bad effects of zenite slowly wear off.

This leaves us with a revised set of facts and an explanation.

The disrupters are Troglytes who have been removed from exposure to raw zenite gas that collects in the mines and causes violent behavior and temporary mental inferiority. Once their mental faculties returned to normal, the disrupters were able to out-wit an advanced scientific culture for months.

**Parallels – Star Trek: The Next Generation**

In this episode Worf notices subtle changes in his environment as he shifts from one quantum reality to another. The "Commander Data" of Worf's current quantum universe is trying to determine what might be causing Worf to shift between quantum realities.

Data: I am detecting no temporal anomalies in this system. Perhaps we should attempt to pinpoint the exact moment when events became discontinuous. Do you remember the first change?

Worf: I was in sick bay. Dr. Crusher told me I had a concussion--but I do not remember that happening.

Data: Think back. Are you certain that was the very first change?

Worf: Before. . . Yes, yes. I was in engineering. I felt a wave of dizziness and when I looked up, you and commander La Forge were on the opposite side of the room. And Captain Picard was gone. I thought I had blacked out for a moment and had not observed your movements. And at my birthday party, the cake was chocolate, and then it was yellow and commander Riker told me that Captain Picard was not going to attend and then suddenly he was there.

Data: Hum. We should try to find the commonalities in these events. Who were the people you were with?

Worf: Everyone was at my birthday party. Then I was with Counselor Troi. Then Commander La Forge came in. . . Geordi. . .Geordi was present at all three locations and he was near me in each case just before I noticed the differences. There has to be a connection.

Data: It is possible.

In the next scene, they find that Geordi has died and that his body is lying on a bed in sick bay.

Data: I see nothing that connects these bio-readings to your recent sense of discontinuity.

Dr. Ogawa: What about his visor? [Data investigates the visor.]

Data: I still see nothing unusual. Perhaps we should activate it.

Dr. Ogawa: Hook it up to the diagnostic array and I'll check it out.

Data: The visor is active. [Worf swoons]

Dr. Crusher: Worf, are you alright?

Data: Have you noticed another discontinuity?

Worf: Dr. Crusher was not here. . . .

Mill's method of agreement

|  |  |
| --- | --- |
| factors | effects |
| Birthday party | Geordi | visor | many others | quantum shift |
| engineering | Geordi | visor | Picard | Riker | quantum shift  |
| Troi case | Geordi | visor | Troi | quantum shift  |
| Sick bay case | Geordi's body | visor (on) | Medical staff | quantum shift |
| Therefore, Geordi's functioning visor causes Worf to experience a quantum shift. |

 Geordi's functioning visor is the single common factor that is present each time Worf experiences a shift between alternate quantum realities. Thus, Mill's method of agreement supports the claim that Geordi's visor is causally related to Worf's shifts.

Strictly speaking, if we add the following to the above list, we get an instance of Mill's joint method.

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| --- | --- |
| factors | effects |
| Birthday party | Geordi | Visor (on) | many others | quantum shift |
| engineering | Geordi | Visor (on) | Picard | Riker | quantum shift  |
| Troi case | Geordi | Visor (on) | Troi | quantum shift  |
| Sick bay case | Geordi's body | visor (on) | Medical staff | quantum shift |
| Sick bay case | Geordi's body | Visor (off) | Medical staff | No quanum shift |
| Therefore, Geordi's functioning visor causes Worf to experience a quantum shift. |

**Plato’s Stepchildren – Star Trek: The Original Series**

Captain Kirk, Mr. Spock, and Dr. McCoy are being held captive by a man named Parman who is the leader of a group of travellers who are shipwrecked on a planet named Plato. Subsequent to being stranded, these travellers developed psycho-kinetic powers which they now use to control the body movements of others. They exercise this power in particular on a drawf named Alexander. In this scene, Alexander is questioned by Kirk and the others in the hope that he will provide the information that they need in order to formulate an escape plan.

Kirk: Did the Platonians always have this power?

Alexander: No. Not until we came to this planet.

Spock: Alexander, is it possible for you to recall how long after you arrived here that their power began to develop?

Alexander: How could I forget that? It was exactly 6 months and 14 days after we got here that they started pushing me around.

Spock: And would you know how many months supplies you brought with you?

Alexander: Four, I think. No, no--three.

Spock: That's close enough, Alexander. Fascinating! Their power developed two or three months after they started eating the native foods.

Alexander: That's right.

Spock: Then it is logical to assume that there is a connection between the psycho-kinetic power and the eating of the native foods.

McCoy: Well then why wouldn't Alexander have the same power as the others?

Spock: Perhaps his system cannot absorb the crucial element.

Kirk: Bones, I think it would be a good idea if you took a reading of Alexander's blood.

Alexander: Not that I'm afraid of anything--but will it hurt much?

McCoy: You won't even know that it happened.

Kirk: You still have a tricorder reading of Parman's blood don't you?

McCoy: Of course, Parman possesses the highest order of psycho-kinetic ability and Alexander the lowest in the same environmental conditions.

Spock: The probabilities are that Alexander was born with some biochemical deficiency relative to Platonians.

McCoy: I'll run both their blood samples through for a full comparative test in the tricorder.

Kirk: And if our theory works out--we've got a weapon.

McCoy: The one significant difference between Parman's blood and Alexander's is the concentration of kiranide, broken down by a pituitary hormone.

Kirk: Kiranide. It's a high energy source. That could be it.

Spock: The pituitary hormones confirms the hypothesis. They also regulate body growth.

Alexander: Oh, you mean the same thing that kept me from having the power made me a--dwarf?

Spock: Yes. It's also obvious why Parman kept this little utopia a secret. Anyone coming down here, and remaining long enough, would acquire the power.

Kirk: Exactly. McCoy, there must be a quick way of building up a concentration of kiranide in our blood.

McCoy: It will take some doing, but it's possible.

Kirk: Well--what are we waiting for?

Using Mill's method of difference, Spock argues:

|  |  |
| --- | --- |
| factors | effects |
| Platonians | Eating food from their ship | normal |
| Platonians | Eating native foods | Develop psycho-kinetic abilities  |
| Therefore, as Spock puts it, "it is logical to assume that there is a connection between the psycho-kinetic power and the eating of the native foods." |

Dr. McCoy's question "why wouldn't Alexander have the same power as the others?" encompasses an interesting logical point. Accepting Spock's claim for the moment and only for the purposes of argument, Dr. McCoy points out that his claim could function as the first premise in the following VALID argument:

(1) If someone eats the native foods, then that person will develop psycho-kinetic powers.

(2) Alexander eats the native foods.

----------------------------------------------------------------

(3) Therefore, Alexander will develop psycho-kinetic powers.

However, since the conclusion of this argument is false and the second premise is true, it follows that the first premise--Spock's claim--must be false.

In response to this challenge, Spock uses Mill's method of difference to both distinguish and explain the anomaly.

|  |  |
| --- | --- |
| elements | effects |
| Platonian metabolic systems | presence of pituitary hormone | native food elements K,L,M | K,L,M absorbed | Develop psycho-kinetic abilities |
| Alexander's metabolic system | low levels of pituitary hormone | native food elements K,L,M | L,M absorbed | No psycho-kinetic abilities |
| Therefore, Alexander's metabolic system lacks ability to absorb the element that causes the powers. Or, as Spock puts it, "the probabilities are that Alexander was born with some biochemical deficiency relative to Platonians". |

**Thine Own Self – Star Trek: The Next Generation**

Data: Where is your mother?

Gia: She died about a year ago. Father said she . . . she went to a beautiful place, where everything is peaceful, and everyone loves each other, and no one ever gets sick. Do you think there's really a place like that?

Data: [looks out a window into a starlit sky and apparently vaguely remembering his life on the Enterprise] Yes, I do.

Talur: Rock, fire, sky and water are the basic elements of the universe. They can be found in every object, every animal, every person, everything. The rock in this wood can be felt by its weight and its hardness. If we expose the wood to flame we can encourage the fire within the wood to show itself. We can also see smoke which is part of the sky. The water in the wood is difficult to see. Sometimes the elements are buried deep within the object. But the four elements are always there.

Data: Ahem.

Talur: Yes, Jaden? [Data is going by the name Jaden]

Data: I do not believe that is correct.

Talur: Oh?

Data: I believe you are reasoning by analogy. Classifying objects and phenomena according to superficial observation rather than by empirical evidence. Wood, for example, does not contain fire simply because it is combustible. Nor does it contain rock simply because it is heavy. Wood, like any complex organic form, is composed of thousands of different chemical compounds none of which is fire.

 [later]

 Gia: Are you alright?

Data: Yes. But I do not agree with Talur's assessment. Although, I do have gaps in my memory, I know that fire is not an element.

 [later]

Data: At the moment I am looking for a common event or experience that Gia, Garvin, and Skoran may have shared that could have a causal relationship to their illness.

Talur: Well, they have all lived here in the village for many years. I'm sure they have many common experiences.

Data: Yes. But since the illness struck all three in a relatively short period of time, it's reasonable to assume that experience is recent and unusual.

Talur: Actually, Jaden, encountering you has been the most unusual experience they have all shared recently.

Data: I am aware of that. Excuse me. I am also open to the possibility that I may in some way be the causal factor. However, since you have had a great deal of contact with me and you show no signs of the sickness, I tend to discount myself as a likely candidate.

Talur: Still, it has to be more than just a coincidence that shortly after you arrived people started to become ill.

Data: I agree.

 [later]

Data: I have coated this piece of cloth with a liquid that is used in lamps. As you can see, the cloth becomes luminescent when it is exposed to an energy source. This pendent also appears to be an energy source.

Talur: But where is this pattern of light coming from?

Data: I believe a stream of particles is emanating from the metallic pendent and hitting the cloth.

Talur: I don't see any particles coming from the pendant.

Data: You will see that there are. I can even block them. It would appear that this container was constructed of a material which absorbs or blocks the particles coming from the metal.

Talur: It's a trick.

Data: No.

Mill's joint method:

Case circumstances observation

Gia: Data, metal-- ill

Garvin:Data, metal-- ill

Skoran:Data, metal-- ill

Blacksmith:not Data, metal-- ill

other citizens:not Data, not metal-- not ill

Talur:Data-- not ill

--------------------------------------------------------------

Therefore, the metal is the cause of the illness

By comparing the cases of Gia and Talur, the method of difference implicates the metal. The same holds when comparing the blacksmith with the other citizens. Using the method of agreement on the first three cases supports the believe that either Data or the metal is the cause. But if we consider the cases of Skoran and the blacksmith, the method of agreement indicates that the metal is the cause.

 **Unnatural Selection – Star Trek: The Next Generation**

Dr. Kingsley and other scientists have genetically engineered some advanced humanoid children. The first officer of the space ship the Lantree visited the genetics laboratory and two days after he returned to his ship, every member of the crew was found dead of old age. The Enterprise is investigating and Dr. Kingsley has requested that the Enterprise remove the children from the lab because they are unaffected. Piccard is cautious, but Pulaski arranges a test to see whether or not the children carry the disease. Pulaski exposes herself to one of the children in a shuttle craft. She and Data are investigating the cause of the disease in the genetics lab.

Dr. Pulaski Commander, what have you got?

Data The answer, I believe Dr. The Lantree was not the source of the disease. But it was the trigger.

Dr. Kingsley Trigger?

Data The Lantree's first officer exposed your children to Falusian flu for the first time. Their active immune systems set out to attack the virus and once it was triggered it kept going. The antibody created an unexpected side effect. It alters the genetic makeup of normal humans. This is a comparison of altered and normal DNA. These are the two molecules that have been transposed.

Dr. Pulaski And since our DNA is self-replicating, the process . . .

Data . . .Is irreversible.

Dr. Pulaski Judging from what happened on the Lantree, anyone is a carrier once they're infected.

Dr. Kingsley Ooh.

[later]

Captain Piccard Have you made any progress Doctor?

Dr. Pulaski I'm afraid so, Captain. The children don't carry the disease, they are the cause.

Captain Piccard What do you mean?

Dr. Pulaski Their advanced immune systems created an antibody that changes normal DNA. The altered genes are the ones that control aging.

Captain Piccard Then why did it attack you more quickly than Dr. Kingsley?

Dr. Pulaski The enclosed environment of the shuttle craft concentrated my exposure. The Lantree's first officer carried the antibody onto his ship. It had the same effect on his crew.

The first challenge is to determine what is happening. Data likely goes through an argument something like the following, which is an example of Mill’s method of difference.

|  |  |
| --- | --- |
| factors | effects |
| Staff of genetics lab | exposure to children | No Falusian flu | No aggressive antibodies |
| Previous visitors to lab | Exposure to children | No Falusian flu | No aggressive antibodies |
| Lantree Captain visits lab | Exposure to children | Falusian flu | Aggressive antibodies |
| Therefore, exposure to Falusian flu caused the children’s bodies to develop the aggressive antibodies. |

In the scene, we see an argument that uses both the method of agreement and the method of difference.

|  |  |
| --- | --- |
| factors | effects |
| Enterprise crew | No exposure to children’s antibodies | Normal aging rate; normal DNA |
| Everyone else in the universe | No exposure to children’s antibodies | Normal aging rate; normal DNA |
| Dr. Pulaski | Exposure to children’s antibodies | Accelerated aging rate; abnormal DNA |
| Lantree crew | Exposure to children’s antibodies | Accelerated aging rate; abnormal DNA |
| Therefore, exposure to the children’s antibodies likely causes the altered DNA that accelerates aging. |

Finally, Picard asks for an explanation for the fact that Dr. Pulaski appears to be aging more rapidly than what happened to the lab staff or the Lantree crew. She offers an argument that uses

Mill’s method of concomitant variation.

|  |  |
| --- | --- |
| Factors | effect |
| Genetics lab staff | Very low exposure to antibodies | Low increased rate of aging |
| Lantree crew | High concentration of exposure to antibodies | Rapid rate of aging |
| Dr. Pulaski | Very high concentration of exposure to antibodies | Very rapid rate of aging |
| Therefore, exposure to the antibodies likely causes the increased rate of aging. |

She goes on to point out that given her highly concentrated exposure, she should be expected to age more rapidly than the staff at the genetics lab.

**Star Trek IV: Voyage Home**

**Reframing An Issue**

 Most people tend to cling too rigidly to the first set of interpretative categories or frameworks that they use to understand a situation. The ability to adopt a critical perspective on an issue; the ability to bring to light alternative interpretative possibilities and then to reconceptualize a situation in a more fruitful manner, is a vital critical thinking skill.

 In the scene that follows, the characters are initially caught up in a single narrow conceptualization of an issue. Their ability to establish a critical distance from their initial take on a problem is an indispensable step in their effort to find a solution. In the movie *Star Trek IV: The Voyage Home*, a probe in orbit around the Earth is sending a transmission into the Pacific ocean. The side effects of this action will soon destroy the Earth. The crew of the Enterprise is informed of this threat and a copy of the probe's message is sent to them.

Admiral Kirk: Uhura, let us hear the probe's transmissions. [Uhura plays the transmission] Spock, what do you make of that?

Mr. Spock: Most unusual! An unknown form of energy of great power and intelligence. Evidently unaware that it's transitions are destructive. I find it illogical that it's intentions should be hostile.

Dr. McCoy: Really??! You think this is it's way of saying, "Hi there!" to the people of the Earth?

Mr. Spock: There are other forms of intelligence on Earth, Doctor! Only human arrogance would assume the message must be meant for man.

Admiral Kirk: You're suggesting the transmission is meant for a life form other than man.

Spock: At least a possibility, Admiral. The President did say it was directed at Earth's oceans.

Admiral Kirk then asks Uhura to adjust the signal for temperature, density, and salinity so that they can hear what the signal would sound like under the ocean. She does this and after further investigation Spock announces:

Mr. Spock: As suspected. The probe's transmissions are the songs sung by whales.

Capt. Kirk: Whales!!

Mr. Spock: Specifically, humpback whales.

Dr. McCoy: That's crazy. Who would send a probe hundreds of light years to talk to a whale?

Capt. Kirk: Its possible. Whales have been on Earth far earlier than man.

Spock: Ten million years earlier. And humpbacks were heavily hunted by man. They have been extinct since the twenty first century. It is possible that an alien intelligence sent the probe to determine why they lost contact.

Dr. McCoy: My God.

Capt. Kirk: Spock could the humpback's answer to this call be simulated?

Spock: The sounds but not the language. We would be responding in gibberish.

Capt. Kirk: Does the species exist on any other planet?

Mr. Spock: Negative. Humpbacks were indigenous to Earth. Earth of the past.

Capt. Kirk: Well we have no choice. We must destroy the probe before it destroys Earth.

Mr. Spock: To attempt to do so would be futile, Admiral. The probe could render us neutral easily.

Capt. Kirk: We can't just turn away. There must be an alternative.

Mr. Spock: There is one possibility. But, of course, I cannot guarantee success. We could attempt to find some humpback whales.

Dr. McCoy: You just said that there aren't any, except on Earth of the past.

Mr. Spock: Yes, Doctor. That is exactly what I said.

Dr. McCoy: Well in that case. . . Now, wait just a damn minute . . .

Capt. Kirk: Spock, start your computations for time warp.

This scene exemplifies two crucial reformulations. First, Starfleet command and everyone else has assumed both that the probe is hostile and that it's message is intended for mankind. Spock ability to question each of these initial assumptions allows him to see the problem in a different and more fruitful way. Second, Captain Kirk's approach to the issue is restricted to dealing with the crisis in the current time frame. So long as this conceptualization of the problem dominates, no solution is available. However, Spock breaks free from the limitations of this initial framing of the issue and this step enables him to consider the time-travel alternative. His ability to reframe issues in this manner is a wonderful example for any aspiring critical thinker.

The ability to reframe an issue is not exclusively a function of cognitive intelligence. Rather, it has always seemed to me to involved a particular kind of intellectual virtue or habit of mind. Openness, patience, pluralism, and the willingness to consider a problem from multiple levels or dimensions are the kinds of virtues that we can and should encourage in our students.

I suspect that the aim of developing these habits of mind are, for most critical thinking teachers, only an implicitly desired student outcome. We tell ourselves that such habits of mind will develop as a side effect of learning the other skills that we directly teach. Although I do not have a lot to say about directly teaching these virtues, I think that it is worthwhile to identify them as explicit aims and to provide students with a few models that they can use to guide their progress.

First Problem

Initial assumptions:

(1)The alien craft is hostile.

(2)The transmission/message is intended for mankind.

Initial conclusions:

(3)We should defend ourselves from attack.

(4)The transmission/message is hopelessly unintelligible.

Reframed insight:

 (1)The probe might not be hostile.

(2)The message might be intended for some non-human intelligence.

Reframed conclusion:

(3)We should not necessarily respond as if we are being attacked.

(4)We should expand the scope of our interpretive efforts.

Second Problem

Initial assumptions:

(1)This crisis must be dealt with by using currently available resources.

(2)The necessary resources are not currently available.

Initial conclusion:

(1)We are in a hopeless situation.

Reframed insight:

(3)Backwards travel in time would permit the retrieval of currently unavailable resources.

Reframed conclusion:

(4)We can do something about this situation.