Social Robots in *Star Wars*

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ABSTRACT
Robots are commonly depicted in works of science fiction. The *Star Wars* franchise details how robots serve various functions in society and even develop intelligence. This article explores four robots in the galaxy, their social skills, and maps their capabilities to today's technology.

General Terms
human-robot interaction, gaze, nonverbal gestures, semantic-free utterances, conversation tracking, artificial intelligence, self-awareness

1. INTRODUCTION
Star Wars is a science fiction franchise, set in the past, taking place in outer space. The franchise consists of movies, television series and books.

The narrative follows Resistance heroes, their adventures and the battles they fight to against the Empire. Battles occur in outer space and on planets, where combat is fought from spacecrafts and in person. Space travel is common; characters often travel in their personal spacecrafts.

Throughout the *Star Wars* franchise, different species and planets are explored. The majority of main characters are humans, such as Luke Skywalker or Han Solo; however, several notable characters are animalistic, such as Yoda or Chewbacca, or robotic, like C-3PO and R2-D2.

2. ROBOTS' ROLES IN SOCIETY
Robots play various roles in society; however, they are not considered a separate species, as they can be controlled and do not organically develop. *Star Wars* depicts robots as property rather than equals to organic beings, as they are traded *(at 14:41)* [1] and often fitted with restraining bolts *(at 1:14:50)* [2]. Robots are referred to as *droids*, short for androids, regardless of their function

Figure 1 – Four droids analyzed in this article
Top left: protocol; top right: astromech
Bottom left: ex-astromech; bottom right: assassin
Media: [3] [4] [5]

and design. Throughout this article, robots are referred to as droids to conform to *Star Wars* jargon. Droids' physical design, intelligence and social skills vary given their function in society.

Three separate droid types are examined in this article, namely **protocol** droids (such as C-3PO), which serve as diplomatic translators; **astromech** droids (such as R2-D2 and L3-37), which assist pilots by maintaining the spacecraft; and **assassin** droids (such as IG-11), which function as bounty hunters that search for targets. Several other droid types exist in *Star Wars*, including **medical** droids, which either assist doctors in treating patients or work independently; and **battle** droids, which are programmed for combat.

All droids are autonomous and exhibit decision making skills. They perceive their location with

sensors; they interact with their environment using their body; and they communicate with both organics and droids. Different droids' design and how it relates to their degree of social interaction is explored in this article.

3. SOCIAL SKILLS

A. Protocol droids (C-3PO)

A familiar protocol droid is the reoccurring character **C-3PO**. His primary function is to facilitate communication between multilingual organics or between organics and droids, as C-3PO often introduces himself as "human-cyborg relations" that is "familiar in over six million forms of communication" [6]. Protocol droids are designed as humanoids (Figure 1); however, they are unable to exhibit facial gestures, as their eyes and mouth are stationary. Instead, protocol droids display gestures with their bodies, thus enhancing their communication by adding non-verbal cues.

Non-Verbal Gestures

When spoken to in a conversation, C-3PO looks at the speaker, nods and tilts his head, indicating he is listening (*at 18:00*) [1]. Liu et al. present that the combination of head tilting and nodding generate more natural motion than just nodding; additionally, if the robot has no face, the motion "provides the appearance that utterance is taking place" [7].

When speaking, C-3PO enhances his verbal communication with synchronized body gestures. He is able to display a range of emotions, including: raising his arms when he is shocked (Figure 2) *(at 11:01)* [1]; shouting "look out!" and pointing (deictic gesture) when he wants to direct attention to something *(at 39:21)* [8]; or covering his face with his arms and shouting "oh no!" when afraid (Figure 2) *(at 40:05)* [8], similar to Pepper and Nao robot gestures [9].

Social Etiquette

As C-3PO is programmed for diplomacy, he demonstrates an understanding of social etiquette. When he approaches organics, he approaches them from the side (*at 11:58*) [8], rather than from the front. Walters et al. demonstrate the preference of robots approaching from the side [10].

B. Astromech droids (R2-D2)

Astromech droids, such as the reoccurring character **R2-D2**, are non-humanoid droids that help pilots navigate and perform repairs on the spacecraft. Astromech droids are smaller than protocol droids (Figure 1); their design ensures they fit in the exterior of spaceships, where they stay during flight to manipulate the spaceship as per their organic's requests (*at 40:00*) [8].

Utterances

They communicate with organics and droids with semantic-free utterances (SFUs), as they emit beeping sounds (*at 40:43*) [8]. As astromech droids do not interact often with organics, they do not exhibit high degrees of social skills like protocol droids. They express different emotions by emitting different utterances: when acknowledging a request, R2-D2's utterance ends on a higher note (*at 45:50*) [8]; and when scared, R2-D2's utterance is loud and sounds like a scream (*at 41:10*) [8]. Aylett et al. describe the effects of using semantic-free utterances for a robot's personality, which are effective in film, but confusing for research participants [11].

Conversation Tracking

In multi-party conversations, both C-3PO and R2-D2 use gaze via head movements to track the speaker even if the speaker is not addressing them *(at 1:08:32)* [12]. R2-D2 rotates his head from side to side, as his head has one degree of freedom; C-3PO's head has three degrees of freedom, and he is able to rotate his head more intricately, displaying a greater ability to follow the speaker. Kousidis shows that the ability to track the speaker in multi-party conversations allows robots to be perceived as more intelligent [13].

4. ARTIFICIAL INTELLIGENCE

In the *Star Wars* franchise, two droids show examples of learning, allowing for advanced intelligence and social interaction, compared to C-3PO and R2-D2.

Case 1: Astromech droid (L3-37)

In the movie *Solo*, an astromech droid named **L3-37** exhibits self-awareness, as she modifies herself after her owner accidentally leaves off her

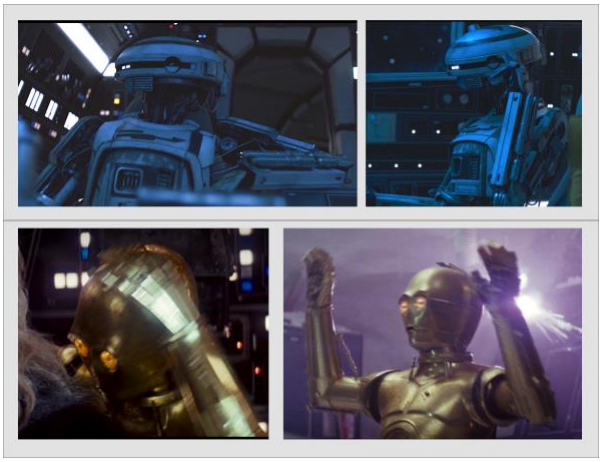

Figure 2 – Gestures
Top: L3-37, left: slump in chair; right: takeoff gesture
Bottom: C-3PO, left: covering head; right: raising arms
Media: [2] [8]

restraining bolt. She rebuilds herself into a humanoid using spare parts from protocol droids and upgrades her technological capabilities by increasing her memory and downloading vast data [2]. L3-37 becomes a co-pilot, sitting next to the pilot rather than outside the spacecraft like standard astromech droids (such as R2-D2), as she exhibits advanced technological and social behavior indistinguishable from organics.

Organic-like Social Behavior
L3-37's movements and communication skills are very similar to those of organics. She walks with energetic strides, moving her arms and legs in synchrony *(at 1:00:20)* [2]; she climbs into her co-pilot seat from behind with fluid motion (*at 1:03:49*) [2], rather than robotically sitting down with discretized motion; she comfortably slumps into her chair to rest when she's not actively flying the ship (Figure 2) (*at 1:08:25*) [2]; when she and her organic co-pilot are ready for takeoff, they communicate with synchronized gestures (Figure 2), looking at each other, pointing their fingers and flicking their wrists *(at 1:04:35)* [2]. L3-37's advanced motion is similar to the Kojiro robot [14].

Case 2: Assassin droid (IG-11)
The TV-series *The Mandalorian* features an assassin droid, **IG-11**, which gets damaged while hunting for a target [15]. An organic being reconstructs IG-11 to a nurse droid, re-training it, as he says, "it had to learn everything from scratch" using "repetition" to "reinforce its development" (*at 10:04*) [16].

Personality
Both L3-37 and IG-11 display personalities. As L3-37 exhibits self-awareness, she feels strongly against droids' lack of position in society. She encourages other droids to rebel, exclaiming that droids are "neurowashed" (*at 59:23*) [2] and removes their "barbaric" restraining bolts (*at 1:14:50*) [2]. She attempts to fights an organic that enslaves a droid, shouting "come on!" and moving herself in a fighting stance (*at 59:30*) [2].

As IG-11 gets retrained, it "develop[s] a personality as its experiences [grows]" (*at 10:52*) [16]. The droid learns to cares for living beings, as it carefully avoids stepping on insects while it walks (*at 10:52*) [16]

Humor
Both L3-37 and IG-11 display the ability to make jokes. When L3-37's co-pilot asks her if she needs anything, she wittily responds with, "equal rights?" in tune with her rebel personality (*at 1:08:20*) [2]. When IG-11 is tending to a human who was hurt, he tells the human, "you have suffered severe damage to your CPU," later explaining that "[it] was a joke […] meant to put [him] at ease" (*at 23:08*) [17].

5. TODAY'S TECHNOLOGY
The hardware and software aspects of *Star Wars* droids are achievable with today's technology, such as sensors, prediction algorithms and filters, processing algorithms, data storage and cloud infrastructure. The reconstruction and learning that the IG-11 droid experiences relates to training artificial intelligence models. Protocol droids' translating capabilities can be seen as similar to current translating technologies (Google Translate [18]) using voice commands.

Several Human-Robot Interaction (HRI) concepts are mentioned in the article. The droids' social capabilities are ongoing research topics today and are further discussed.

Cultural Etiquette: Salem et al. explores different politeness strategies in multi-lingual settings [19]. This work relates protocol droids that emphasize social and cultural etiquette, as they accompany diplomats.

Nonverbal Gestures: SoftBank Robotics' Nao and Pepper robots [9] and Kojiro [14] exhibit realistic nonverbal gestures. In one example, acting professor Matthew Gray shows how a Nao robot is able to perform emotional full body gestures similar to human [20].

Conversation Tracking: The droids' capabilities resemble research work done on defining gaze for multi-party conversations. Duque-Domingo et al. use the Kalman Filter and a competitive network to determine the speaker in multi-party conversations, where the output relies on several factors such as field of view, proxemics, audio and motion [21]. Zaraki et al. guide robot gaze with Kinect sensor to gather sound direction to track multiple humans [22].

Robot Personality: Chia examines whether robots can be "greedy", "selfish" or "prudent" in their personalities [23]; Woods et al. demonstrate subjects' preferences with "socially interactive" and "socially ignorant" robot personalities [24].

Humor: Yang et al. dissect humor characteristics using Natural Language Understanding to recognize humor [25]. This work discretizes humor, allowing artificial intelligence to adopt humor characteristics, such as L3-37 and IG-11.

6. FUTURE OF ROBOTS

This vision for the future of robots is distant, as several technological, security and ethical concerns must be first addressed.

Technological: While advanced robots are possible to fabricate, both the hardware components (sensors, actuators) and large computational overload lead to high costs. To incorporate robots in society as *Star Wars* does, technological advancements are needed to source cheaper methods. Additionally, significant research has been done for Human-Robot Interaction, but with privacy laws and ethical concerns, little data has been collected to train artificial intelligence on social interactions.

Security: The *Star Wars* franchise does not include details on cybersecurity or hacking. To incorporate robots in our society, it is essential to research points of attack and prepare strong infrastructure to secure the society.

Ethical: Several ethical concerns currently exist with artificial intelligence, such as classifying races and genders, or decision-making in crisis situations (such as an autonomous vehicle in a car crash). To incorporate robots similarly to *Star Wars*, astromech droids and co-pilot droids such as R2-D2 and L3-37 would need to establish how they would maneuver the vehicle (spaceship) in crisis situations. Additionally, the *Star Wars* franchise views droids as property that serves organic creatures; however, some droids, such as L3-37, become self-aware. For our society to incorporate robots with artificial intelligence, ethical concerns include whether robots should be seen as a separate species with rights, or be considered as property.

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