The Quiet Professional: An investigation of U.S. military Explosive Ordnance Disposal personnel interactions with everyday field robots

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Abstract

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This research explores interactions between Explosive Ordnance Disposal (EOD) personnel and the robots used every day. It was designed to richly describe the nuances of these interactions, especially those related to operator emotion associated with the robots. In this study, the EOD human-robot dynamic was investigated by interviewing 23 EOD personnel, collecting demographic information, and using one-on-one semi-structured interviews. Study results suggest EOD personnel relationships among peers and team members showed distinct patterns in human-human relationships as part of a Human-Human Interaction Model (HHIM) in terms of expectations of performance, and beliefs, values, and actions, related to their work. Findings described here also suggest performance expectations and other factors of the HHIM of teamwork do not map onto EOD personnel human-robot interactions. However, in some cases there is a tendency for personnel to ascribe human traits to robots, creating nuanced human-technology relationships introduced here as the Robot Accommodation Dilemma (RAD). These findings have implications for future personnel training and the refinement of robot design considerations for EOD and other fields that rely on critical small group communication and decision-making skills.

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GLOSSARY OF MILITARY ACRONYMS

AFB	Air Force Base
AI	Artificial Intelligence
C-IED	Counter-Improvised Explosive Device
Capt	Captain (Air Force, Marine Corps)
CPT	Captain (Army)
DARPA	Defense Advanced Research Projects Agency
DOD	Department of Defense
EOD	Explosive Ordnance Disposal
HBIED	House Born Improvised Explosive Device
IED	Improvised Explosive Device
IND	Improvised Nuclear Devices
JIEDDO	Joint Improvised Explosive Device Defeat Orgnatization
K-9	Canine, or Military Working Dog
Maj	Major (Air Force, Marine Corps)
MAJ	Major (Army)
MWD	Military Working Dog
MOS	Military Occupational Specialty
MSG	Master Sergeant
MGySgt	Master Gunnery Sergeant
NCO	Non-commissioned Officer
PO1	Petty Officer First Class
RSP	Render Safe Procedures
SOF	Special Operations Forces
SCPO	Senior Chief Petty Officer
SSG	Staff Sergeant (Army, Marine Corps)
SSGT	Staff Sergeant (Air Force)
TTP	Tactics, Techniques, and Procedures
TSgt	Technical Sergeant
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
US	United States
USA	United States Army
USAF	United States Air Force
USMC	United States Marine Corps
USN	United States Navy
UXO	Un-Exploded Ordnance
VBIED	Vehicle-Borne Improvised Explosive Device

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Andrew S. Tedlow was a calm touchstone for me during the writing process. Other than sporadic bursts of Bob Dylan and Captain Beefheart drifting in from his workspace, he was also a quiet occasional co-home-office-sharer, for which I am very appreciative. I will forever be grateful for his generosity, good nature, and encouragement.

I remember when my father, Earl M. Wajdyk, would bring me to his classes when I was a little girl and let me sit in a real desk like the college students to watch him teach. I am sure the fond memories and associations I have of growing up on university campuses while he earned his own Ph.D. helped encourage me toward also achieving this goal.

My mother and step-father, Susan and Steven Swanson, have patiently gone through all the unsettling stages of watching their adult child navigate through a doctoral program. I am grateful for their sense of humor and continuing support while I pursue my goals.

Dedication

I dedicate this work to my grandfather, Werner Poli, my Opa. His passion for learning everything under the sun will live on in any contribution I make to the world.

INTRODUCTION

The nature of Explosive Ordnance Disposal (EOD) work is unique within military specializations. EOD personnel go through some of the most rigorous specialized training in the military. The initial training period includes a component all members of the Armed Forces attend together in Eglin, Air Force Base (AFB), colloquially referred to as "The Schoolhouse." Once graduated into the formal EOD role, the job demands academic and physical prowess.

Like some other military specialties, small-group teamwork is critical to the job, but EOD work also demands ongoing effective verbal communication between group members in order to successfully complete the team-oriented missions. Also unusual in the context of more typical military structure, EOD team members are frequently encouraged to give input to the Team Leader about each mission's situation while it is in progress. This procedure is based on the assumption that every individual is a Subject Matter Expert (SME) with a valid perspective worth considering in a collaborative effort before the Team Leader decides on the final group actions.

As the nature of EOD training and work evolves within the military, and because of a surge in Improvised Explosive Device (IED) encounters, modifications are being made to aspects of EOD teamwork. These include team size, the age of people promoted, and increased reliance on technology such as robots. One of the most critical standard tools EOD personnel use are the semiautonomous teleoperated robots that assist in Render Safe Procedures (RSP), helping to disable or mitigate the threat of explosives.

PROBLEM STATEMENT

Currently, EOD personnel rely heavily on robots as an important tool to assist in render safe procedures for unexploded ordnance. Consequently, if problems with the human-robot interactions are overlooked, there is a continued danger to human lives and mission outcomes from the unidentified issues in these interactions.

There has been no inductive research approach to investigating the dynamics of the EOD personnel's interactions and experiences with robot models used every day and the associated emotional aspects of these interactions. These interactions include how emotion in human-robot interaction affects operator decision-making and, therefore, mission outcomes. EOD human-robot work presents unique emotional challenges that must be considered as robot design and team size evolves. Popular news stories have reported EOD personnel bonding with and becoming attached to their robots (Garreau, 2007; Rose, 2011).

The act of attachment and its related concepts of bonding, cohesion, and trust may impact operator decision-making. Discovering what, if any, of these human factors plays into the human-robot dynamic can shed insights into leveraging the robot design elements or contexts of use that trigger positive and negative operator reactions. Addtionally, in order for human-robot teams to be effective, research is needed into the whole system that the individual team members are a part of, and how these factors ultimately shape the interactions at micro levels. For the desired outcomes of successful missions and safe personnel and civilians to be achieved, the preferred effect is that EOD human-robot interactions are as fluid as possible, and both humans and robot can overcome obstacles efficiently.

Establishing a basic understanding of the system provides a base knowledge that promotes the further identification of things that impact the human-robot experiences, and of ways to improve human-robot training, advance robot design, and the effective support of mission interactions between human and robot.

Thus, in order to develop a basis of understanding on which any coherent discussion of robot design and use within close teams such as EOD must be based, this study delves into the human user experience of EOD human-robot interactions. To achieve this goal, the study uses qualitative methods and examines the context, expectations, attitudes, and emotions that are part of these human-robot relationships.

PURPOSE OF THE STUDY

This study examines how United States military Explosive Ordnance Disposal personnel interact with robots used every day. Two research questions guided this work:

1. What are the activities, processes, and contexts that influence or constrain every day EOD human-robot interactions?
2. What human factors are shaping the (robotic) technology?

There is currently no published, publicly available research on soldiers and robot interactions using an inductive approach to methodology. In order to answer the research questions, this study focuses on discovering emerging patterns in the experiences of soldiers and their interactions with robots. Then, the data are analyzed to find and describe these emerging patterns of information that indicate ideas, concepts, behaviors, social structures, and ideas relevant to illuminating the complex set of interactions that occur between users and robots in EOD work. The theory-building in this study uses the existing theoretical models of human-human and human-robot interaction. Then, based on these, it builds a conceptualization of theory that is applicable in the specific EOD setting.

NEED FOR THE STUDY

> In the 20th century, artillery was the greatest producer of troop casualties. The IED is the artillery of the 21st century.
>
> Lieutenant General Michael Barbero
> Director, Joint IED Defeat Organization,
> JIEDDO Counter-IED Strategic Plan:
> 2012-2016

In the United States military, Explosive Ordnance Disposal (EOD) technicians perform a vital role in the military, effectively and safely defusing U.S. and foreign chemical, biological, radiological, and nuclear (CBRN) unexploded ordnance (UXO), including Improvised Explosive Devices (Department of Defense, 2006). U.S. military EOD specialists also work stateside assisting local and state civil authorities to disarm and dispose of hazardous devices. Various other official EOD responsibilities include support of the U.S. Secret Service, State Department, and other Federal agencies (Cooper, 2011; United States Army, 1997). These include the U.S. Department of Homeland Security, U.S. Customs Office, and Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF). Their services protect the President, Vice President, and other officials and dignitaries, as well as providing a critical part of security at large international events.

United States Armed Forces Explosive Ordnance Disposal specialists also train and assist domestic civilian law enforcement personnel (Larry, 2008, para. 2; National EOD Association, 2012; United States Army, 1997,) and international friendly and allied force military EOD specialists (Gibson, 2009; Owolabi, 2010, para. 1; Valentin, 2011).

EOD personnel are relatively new to the history of the U.S. military, but have found an unfortunate new significance in recent years due to the increased use of Improvised Explosive Devices in warfare. Improvised Explosive Devices are essentially homemade bombs, often positioned roadside in a very grassroots, non-military fashion by insurgents. IEDs are an alternative style to conventional weapons, often built by untrained people, and ironically proving to be as dangerous — or more — than standardized military tactics. Groups using IEDs as a preferred method adapt their technology quickly, with associated tactics, techniques, and procedures (TTPs) evolving in shorter and shorter cycles (Wilson, 2007). IEDs vary in design and may contain many variations of its components, such as detonators and explosive loads. Typically, antipersonnel IEDs include shrapnel-generating objects such as nails.

Mines, in contrast to IEDs, are usually based on a conventional design and are standardized and mass-replicated. IEDs take many forms, and are triggered by an assortment of methods, including infrared or magnetic triggers, remote control, or pressure-sensitive bars or trip wires. Multiple IEDs are sometimes wired together in a daisy-chain to attack a convoy of vehicles along a road. There is always the threat that toxic chemical, biological, or radioactive material may be an added component of the explosion, creating other severe effects beyond the shrapnel, concussive blasts, and fire normally associated with bombs.

Variations of IEDs include the Vehicle Borne IED (VBIED), commonly known as a car or truck bomb, and the House Borne IED (HBIED), created when an entire home or similar structure is rigged to detonate. Insurgents will often watch any EOD investigative activities in order to set off the explosive strategically and detonate it remotely to cause the most harm, or use the IED to lure EOD personnel into the range of sniper fire.

A critical tool in the first line of any EOD teams' defense against these threats is the use of various mobile robots that perform dangerous tasks such as UXO disposal, vehicle inspection for hidden IEDs, and advance scouting of dangerous transportation routes. The key reason to use robots to detect, inspect, or disarm IEDs is to distance EOD personnel from the danger, thereby reducing the chance of human injury or death.

The rise of IED use cannot be overstated. In 2007, IEDs caused over 70 percent of all American combat casualties in Iraq and 50 percent of combat casualties in Afghanistan, including fatalities and wounded (Wilson, 2007). The impact of IEDs on civilians in areas of conflict has increased alarmingly in recent years, too. The United Nations Mission Assistance in Afghanistan (UNAMA) officially stated, "In incidents where intended targets appeared to be military, those responsible for placing or detonating IEDs showed no regard for the presence of civilians and no evidence of distinguishing between civilian and military targets in violation of the international humanitarian law principles of distinction, precaution and proportionality" (2012, p. 10).

UNAMA reports IEDs are the biggest cause of death in Afghanistan's armed conflict, and recorded the deaths of 340 civilians, and 599 additional injuries from January to September of 2012 (UNAMA press release). The *Afghanistan Annual Report on Protection of Civilians in Armed Conflict* stated that in 2010, 40 percent of female civilian deaths and 44 percent of child deaths were a result of IED explosions and related suicide attacks (2011).

According to an official of the Department of Defense's Joint Improvised Explosive Device Defeat Organization (JIEDDO), military data reports insurgents in Afghanistan plant up to 1,400 IEDs per month (Dreazen, 2011). At the peak of the Iraq war, there were over 4,000 IEDs planted per month (Mora, 2010). Outside of Iraq and Afghanistan in 2011, from January to November, there were 6,832 IED events globally, averaging 621 per month, resulting in 12,286 casualties in 111 countries (iCasualties.org, 2011; JIEDDO, 2012a). Excluding Afghanistan and Iraq statistics, global IED casualties reached their peak in May 2012 with approximately 1800 people wounded and almost 600 killed in May alone (JIEDDO, 2012b).

In 2010, the U.S. military increased the number of road-clearing teams in Iraq from about 23 to 56 (Flaherty, 2010) and in 2011, augmented the road-clearing troops in Afghanistan from 12 to 75 (Dreazen, 2011). Reported numbers vary, but there are currently about 3,000 tactical robots in Iraq and Afghanistan used for reconnaissance and UXO sweeping (Osborn, 2010, para. 1; Singer, 2010), with about 2,000 ground robots in Afghanistan alone (see more detail on pp. 9-10), a ratio of approximately one for every 50 troops (Axe, 2011).

Unfortunately, these statistics tell only part of the story as IED threats increase as a method of warfare and terrorism every year, and represent greater than ever hazards to worldwide military personnel, domestic first responders, and civilians. Although EOD personnel work in many different situations with a comprehensive range of Unexploded Ordnance (UXO) the regrettable increasing popularity of IEDs as a weapon have been a significant springboard for some of the rapid changes within the EOD field in terms of recruitment, training, team structure, and tools used.

As an example of current challenges that EOD operators and robots face, the terrain and human-made structures of Afghanistan present an obstacle-ridden environment that can be taxing to robotic exploration, even with the best of human assistance. Currently, EOD robots are generally wheeled or tracked, and do not resemble humans in appearance. Furthermore, they lack a humanlike ability to move nimbly in a challenging outdoor or indoor environment. A humanoid robot with biped legs and dexterous arms and hands could accomplish EOD tasks smoothly in difficult terrain via human operator control: They are able to move about in buildings, climb a rocky environment, operate existing machinery, and adroitly handle IEDs made by human hands. In fact, a 2004 Defense Advanced Research Projects Agency (DARPA) poll of U.S. military officers revealed their expectations that humanoid robotic infantry will be integrated by 2025 (Finkelstein & Albus, 2003/2004; Singer, 2009).

Supporting this poll, a 2004 DARPA-funded study of optimal robot forms reported that “humanoid robots should be fielded—the sooner, the better” (Finkelstein & Albus, 2003/2004, p. 4). Because the DARPA arm of the U.S. Department of Defense (DOD) publicly indicates that they are exploring the options of humanoid robot design for use in EOD situations, these statistics and this study focus on American personnel in order to discuss the impact of using humanoid robots in U.S. military EOD teams.

U.S. MILITARY HUMANOID ROBOT DEVELOPMENT

Used in relation to robots, the term Warfighter’s Associate (Everett, Pacis, Kogut, Farrington, & Khurana, 2004) describes a two-fold concept in robotics: a (1) human-supervised platform that (2) employs a natural language interface and can understand and respond to high-level verbal commands, and is therefore semiautonomous. This model was developed in response to the emerging needs of the EOD units in Iraq and Afghanistan for robots with increased capabilities. As part of the Space and Naval Warfare Systems Center--San Diego's (SSC San Diego) research initiatives, Everett et al. (2004) proposed a sophisticated system that would closely assist warfighters, "enabling a very synergistic teaming of human and machine capabilities" (p. 2).

To illustrate their concept, Everett et al. compared the idea to that of law enforcement human-canine teams. They suggested that an anthropomorphic robot design might be better suited for some terrains and situations, while a Warfighter's Associate might be designed as a wheeled device for other scenarios (2004). This concept of a Warfighter's Associate would have a robotic embodiment that is still recognizable as a machine, but with humanlike characteristics. These humanlike traits might include the ability to interact in a human-robot team situation with natural language, and a high degree of autonomy, exhibiting humanlike characteristics of speech and self-directed task-oriented behaviors.

While the level of anthropormorphication of different robot models will no doubt vary depending on their intended use, some U.S. military goals to develop and incorporate more humanlike robots is publicly available knowledge. As cited in their 2004 report, Finkelstein and Albus (2003/2004) presented an *EOD Mission Needs Statement* published by the U.S. Army that plainly discussed EOD requirements for the concept of a humanoid robot:

> *A need exists for a robotic platform that is capable of climbing narrow stairs, climbing ladders, opening doors/hatches, such as water towers, ships' holds, or roofs. The humanoid robot would be capable of climbing both ship and land-based ladders. A humanoid robot would alleviate a need for the robot to be light for transportation, since it would be able to stow itself into an EOD response vehicle. A humanoid robot would also be capable of emplacing a disrupter tool or x-ray rather than the current methodology of mounting the disrupter on the tracked or wheeled robot. (p. 106)*

The Mission Needs Statement goes on to outline disadvantages of the wheeled and tracked (tank-like) maneuvering robotic systems used at the time, citing the robots' weight (weighing hundreds or thousands of pounds) which complicate transport, slow down movement, and cause problems related to scaling different types of terrain. This disadvantage, in turn, prevents the disruption of devices on rooftops or similar tall human-made structures. This statement also suggests investigating Current Off-The-Shelf (COTS) humanoid robots that could be modified for EOD use. In other words, humanoid robot design is clearly being examined as a potential design choice for EOD use.

Figure 1 that follows (Dyess, Winstead, & Golson, 2011), illustrates a movement toward robot squad members that are meant to replace human soldiers. In the figure, the fourth column uses the term “appliqué,” which in common military parlance refers to add-on armor. One advantage of adding armor to an existing resource, such as a tank, is to customize an off-the-shelf product to respond to a specific threat. The “exoskeleton” example of appliqué in Figure 1 shows how human operators can wear a robotic framework in order to improve their performance, as well as aid their protection (Fiddian, 2012).

In addition, the same document includes a graphic (Figure 2) that explains in the “Far-Term” third column a planned movement to full robot autonomy, including “humanoids,” although this illustration does not indicate whether the two elements will be integrated, necessarily.

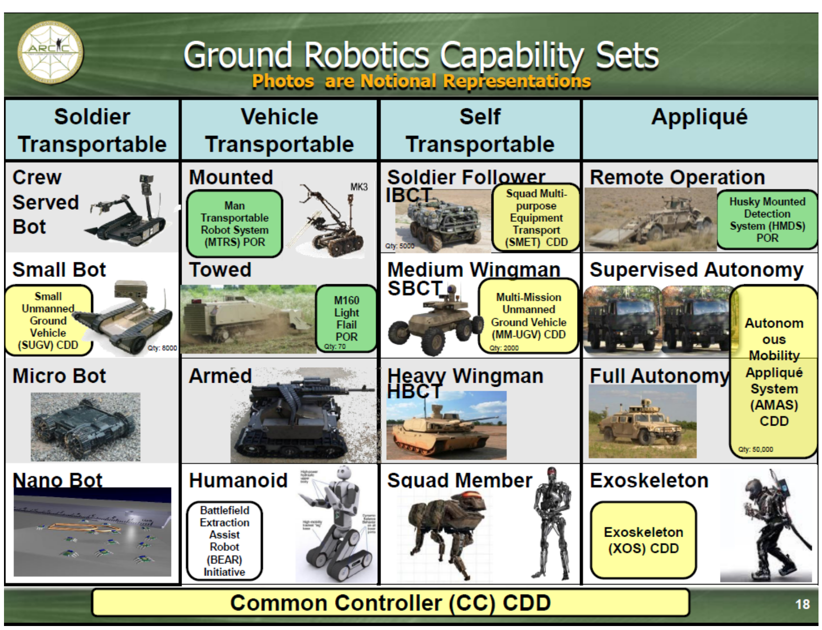

Figure 1. Ground Robotics Capabilities Sets (Dyess, Winstead, & Golson, 2011)

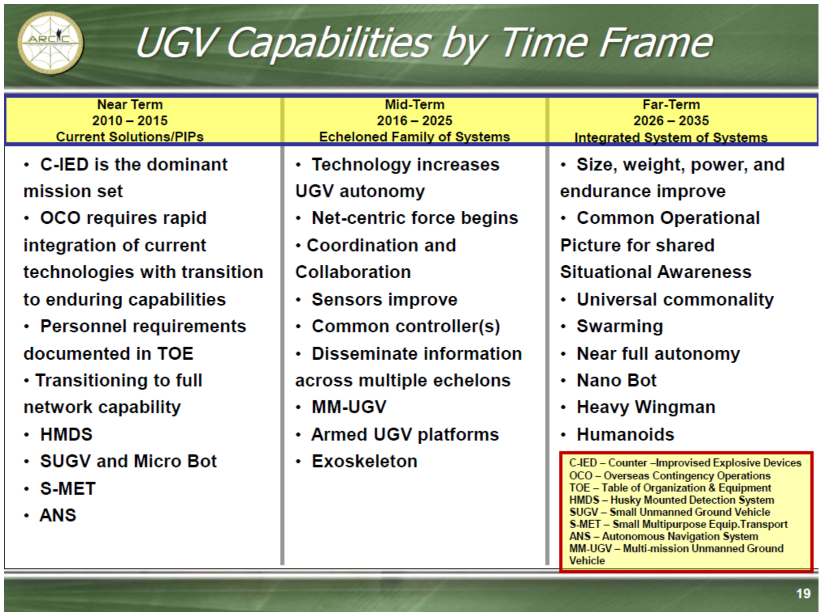

Figure 2. UGV Capabilities by Timeframe (Dyess, Winstead, & Golson, 2011)

Note that in Figure 2, Counter-Improvised Explosive Devices (C-IED) are described as a “dominant mission set” in the near-term list of Unmanned Ground Vehicle capabilities, indicating their development is a high priority in 2010-2015.

However, United States military-funded humanoid robot research and development has already been active for decades and has a rich history of innovation. One of the better publicly known early U.S. military anthropomorphic robot research projects produced the robot “Manny” (Yost, 1989), a humanlike robot with a working artificial respiratory system, but no autonomy or intelligence.

Figure 3. Manny (Image: Idaho National Laboratory, 1988)

Developed to test protective clothing in simulated conditions that are hazardous to humans, Manny was built for the U.S. Army's Dugway Proving Ground (Fisher, 1988). Another humanlike robot from that era includes the U.S. Space and Naval Warfare Systems (SSC) “Greenman,” used for remote presence demonstration (Chatfield, 1995).

More recently, there is the DARPA robotics project is the Autonomous Robot Manipulation (ARM) program, with the goals of developing software and hardware for an autonomous robot able to use human tools and similar agile hands-on “contact tasks” via humanoid robotic arms, wrists, and hands. The current publicly available iteration of the ARM robot platform has an overall humanlike morphology that includes head, face (with stereo cameras for “eyes”), a pan-tilt neck, two arms, hands (with force-torque tactile sensors), and a torso on a mobile base (DARPA, n.d.). When Robert Mandelbaum, former Program Manager for the ARM initiative, was asked to give an example of the task that the ARM hardware and software under development would hopefully produce, he responded using IED disarming as a specific example (Guizzo, 2010), indicating that EOD work would be one area where ARM robots may be used.

In 2010, Vecna Technologies developed the Battlefield Extraction-Assist Robot (BEAR) for the U.S. Army (Gilbert & Beebe, 2010; Silverstein, 2010), a 6'5" humanoid robot prototype that can access most spaces that a human can due to its ability to move either bipedally or tracked (Figure 4). In addition, BEAR can lift up to 500 pounds, carry supplies or wounded soldiers, and is being investigated for other military applications.

Figure 4. BEAR (Photo: Vecna Robotics, 2010)

Even more recently, Boston Dynamics developed Protection Ensemble Test Mannequin (PETMAN), a biped humanoid robot used for testing chemical-resistant apparel in the United States military (Shaker, 2011).

Figure 5. PETMAN (Photo: Boston Dynamics, 2013)

In its final iteration, PETMAN will be “the shape and size of a standard human,” according to Vice President of Engineering at Boston Dynamics, Robert Playter (Edwards, 2010). DARPA has also commissioned Boston Dynamics to develop the Atlas robot that is designed with a torso, two legs, and two arms (C. Brown, 2011; Edwards, 2010; Shaker, 2011). This robot, as shown in Figure 5, has impressively nuanced physical capabilities and can walk upright bipedally with a heel-to-toe walking motion, maneuver sideways in order to move through narrow passages, and use its own forward motion to hurl or swing itself across gaps and between handholds.

The Navy Center for Applied Research in Artificial Intelligence (NCRAI) is developing a bipedal, two-armed robot called Shipboard Autonomous Firefighting Robot, or SAFFiR. SAFFiR is designed to move autonomously through a ship, naturally interact with people, and fight fires. In other words, it will carry out many of the dangerous firefighting tasks that are usually performed by humans (McKinney, 2012). According to a NCRAI press release, the plan is to enable SAFFiR to employ high-level reasoning ability and allow autonomous decision-making and mobility, making the robot a “team member” (McKinney, 2012, para. 4). Natural interaction, multimodal interfaces, the ability to track the focus and attention of human team members will render SAFFiR a very humanlike robot in a military setting.

Additional functionality will eventually include the robot’s ability to understand and respond to gestures, such as human pointing and hand signals, and the robot will track the focus of attention of a human team leader. McKinney further states, “Where appropriate, natural language may also be incorporated” (2012, para. 4).

Other U.S. Navy humanoid robots, such as Octavia and Lucas (Figure 6), may become the next generation of SAFFiR, as their autonomy and social behaviors are integrated into the SAFFiR framework (Carroll, 2012; Webster, 2012).

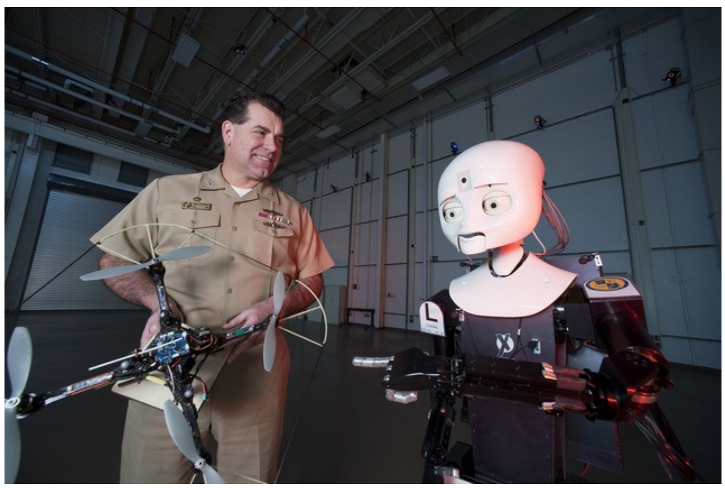

Figure 6. CAPT Paul Stewart and Naval Research Laboratory’s Lucas. (Photo: Jamie J. Hartman/NRL, 2012)

Lucas and Octavia can sense human commands and then decide upon and conduct a series of actions in response. To efficiently and effectively communicate with a human counterpart, the robots’ behavior and appearance demonstrate their internal and “emotional” states. For example, a head tilt indicates the robot is “thoughtfully” considering a course of action. In addition, these robots can use speech to respond to people (Webster, 2012).

This study concentrates on recent robots and robotic concepts with applications specific to EOD work. Currently, robots used for EOD work are either completely remote controlled or semiautonomous, and not easily categorized as humanlike. Below, Figure 7 shows a TALON model typically used on EOD work every day.

Figure 7. TALON IV (Photo: QinetiQ, 2011)

This TALON model is designed to be used for UXO tasks as well as Chemical, Biological, Radiological, Nuclear, Explosive (CBRNE) RSP, security, heavy lifting, and defense or rescue missions (QinetiQ North America, 2013).

Another robot used by EOD personnel in every day work environments is iRobot's Warrior.

Figure 8. 710 Warrior (Photo: iRobot, 2013)

As seen above, the Warrior in some ways resembles the TALON, with a low body and tracked maneuverability. This robot can also climb stairs and carry heavy loads, making it useful for reconnaissance work as well as for route clearance (iRobot, 2013).

In the Literature Review, there is a more detailed discussion of the military as an organization and its impact on EOD culture, EOD individuals, team dynamics, and EOD robot design. Unlike many strictly hierarchical military working environments, EOD specialists, or as referenced in their own argot, “EODs,” are uniquely situated within the military for many reasons, not least of which because they are trained to work and communicate as teams where all members potentially have input for decision-making.

In EOD work, unlike other groups within the military, Team Leaders frequently ask for opinions from all team members, including “junior” or newer members. EODs are formally and informally trained to share information through ongoing communication, which is recognized as a critical part of their decision-making processes since each teammate may have only partial knowledge relevant to solving the problem, different competences and skills, and potentially differing beliefs about the state of the task at hand.

In addition, continuous communication is critical in the event a team member is injured or killed while disposing of unexploded ordnance; the remaining team members must understand why each person in their unit choose and plans to do something and why, so that they may troubleshoot when possible if communication is lost and learn from the outcomes of each unique situation. Although one or two team members may be tasked with operating or maintaining the robot regularly while other members have different expected duties, all team members are exposed to the robots' use as a tool and are frequently in close proximity to the robot regularly.

Given the nature of this type of closely interactive team work, coupled with the utility and frequent use of robots every day in these dangerous team contexts, it is not surprising some soldiers begin to feel legitimate affection for their non-humanoid robots, similar to what they might feel for a pet (Singer, 2009). Anecdotal reports of emotional connections between troops and robots are already becoming part of the popular narrative about how humans have, or might, treat robots (Garreau, 2007; Rose, 20011).

RATIONALE FOR THE CURRENT STUDY AND DESIGN OVERVIEW

Emotionally and culturally laden things such as experiences and interactions can be analyzed, and patterns can be revealed in the internal structure for each individual. These then can be described, which means they have an informational content in addition to whatever qualities or emotions are attached. The basis of much of current human-robot interaction (HRI) research is rooted in human-computer interaction (HCI) and human psychology, often combining self-reporting with physiological and behavioral measures (Kidd & Breazeal, 2005; Carpenter et al., 2008).

There are many models of the research process, most of them devised according to a series of stages. At this stage in human-robot interaction research on user expectations, the researcher's goal is not to suggest a generalizable set of design heuristics, or guidelines, for how to effectively structure a human-robot interaction, or to theorize what all EOD users are like or even what they expect from robots. Rather, this study looks closely at a specific group of users in specific contexts. Examining particular groups of users and their expectations about robots can provide our first insights into how other people in similar situations interact as a team or in collaborative situations with robots. Therefore, this study uses qualitative methods of data gathering.

This work represents one of the first steps in an attempt to disentangle the complex human factors side that are individual- and situation-based in EOD work, thus setting the stage to begin examining user-end effects and variables throughout the course of effective robot development.

IMPLICATIONS FOR THE STUDY

Long-term, this research can be used to help improve the troops' robotics training; enhance robot development specifications to mitigate mission-dependent risks; and improve warfighter and civilian safety in conflict environments, both foreign and domestic. More broadly, findings can be applied to the development of robots that are effective in a variety of human collaborative/team or training situations, especially in stressful conditions (for example, space, defense, and humanitarian relief).

SUMMARY

The next chapter is a review of the literature regarding the theoretical framework of this study and the ecology of EOD work via the organization, people, robots, operating environment and tasks. The *Research Procedures and Methods* chapter details the method of research describing strategy and design, data collection methods and materials, as well as the analysis protocol. The fourth chapter reports the study results and the fifth chapter presents conclusions, implications, and suggestions for further research.

LITERATURE REVIEW

There is no literature on EOD user-robot system interaction as viewed through a social constructivist lens. There is, however, a growing body of literature on human-robot interaction, although the subjects studied are generally not troops and the robots studied are not designed for every day uses and prolonged or dependent relationships. Therefore, this is a baseline study on how Explosive Ordnance Disposal personnel interact on a daily basis with the robots used. The literature discussed in this chapter, along with news press accounts of soldier-robot interaction, helped formulate the research problems and identify the area of study for this work.

SOCIAL CONSTRUCTIVISM AND SOCIAL SYSTEMS THEORY AS THEORETICAL FRAMEWORK

Human-Robot Interaction researchers have investigated different situations and contexts of robot use to explore many human behaviors, expectations, and outcomes. Human-Human Interaction research offers a body of work that has some application toward particular human-robot interactions, especially when looking at the formation of human user attachment and emotion toward robots. The theoretical framework for this study is based on social constructivism, which informed this research.

Social constructivism provides a scaffold for understanding individual behaviors situated in an organizational model like the military by examining how individuals and groups participate in the construction of their perceived social reality. The social constructivist lens requires looking at the ways EOD social phenomena are created via the dynamic interactions between the larger institution and the troops' individual experiences in the world, and how they collaboratively create a culture of shared knowledge, artifacts, and meaning. Although it is possible—and a fruitful area of inquiry—to examine robot development via a social constructivist lens, for the purpose of this study the focus is on the operators' constructs, of which robots are an artifact. Therefore, this work explores and describes the structures, workings, and social origins of EOD personnel interactions and accordingly places robots as a significant part of this system of things.

Social constructivism places an emphasis on the significance of culture and context to understand what occurs in society, and on constructing knowledge based on this understanding (McMahon, 1997). This perspective is closely related with many contemporary theories, including Vygotsky's developmental theories and Bandura's social cognitive theory (Schunk, 2000).

Social constructivism is rooted in specific notions about human-perceived reality, knowledge, and learning. To social constructivists, reality is constructed through human activity; members of a society create properties of the world around them (Palinscar, 1998; Kukla, 2000). In this way of thinking, reality is something that does not exist prior to its social invention, rather than something to be discovered. Similarly, knowledge is also a human product, and is socially and culturally constructed (Gredler, 1997; Prat & Floden, 1994).

Individuals generate meaning via interactions with each other and their environment. Furthermore, through the social constructivist lens, learning is a social process. Learning is not something that occurs only within a person; it is an active process shaped by interactions with external forces (Vygotsky, 1986; Palinscar, 1998). When individuals are engaged in social activities, meaningful learning will take place. Engaging in collaborative learning is therefore a dynamic process of developing a communal "social world" (Palinscar & Herrenkohl, 2002, p. 28).

In social constructivism, the transactional or situated cognitive perspectives focus on the relationship between people and their environment. Through this lens, humans and social relationships are parts of the constructed environment. In turn, the environment is a thing that contributes to the creation of the individual (Bredo, 1994; Gredler, 1997). And so, learning does not take place separately from an environment, but rather as part of it through ongoing interactions. Therefore, if the environment and social relationships among group members change, the tasks of each individual also change (Bredo, 1994; Gredler, 1997; Palinscar & Herrenkohl, 2002).

A shared understanding between individuals whose interactions are based on common interests and assumptions that forms a basis for their communication is termed *intersubjectivity* (Rogoff, 1990). Communications and interactions require socially agreed-upon ideas of the world and the social patterns and rules of language use (Ernest, 1998; Vygotsky, 1986). Thus, intersubjectivity involves the construction of social meanings among individuals. Within groups, these social meanings and knowledge develop and evolve through negotiation (Gredler, 1997; Prawat & Floden, 1994). Through the experience of negotiation and interactions, personal meaning is also affected by the intersubjectivity of the group to which people belong. Consequently, intersubjectivity is the basis of communication and helps people expand understanding of new information and activities among group members (Rogoff, 1990).

A central piece of the concept of social constructivism is learning that is mediated by tools and signs (T. Duffy & Cunningham, 1996; Palinscar, 1998). “Culture creates the tool, but the tool changes the culture. Participants in the culture appropriate these tools from their culture to meet their goals, and thereby transform their participation in the culture” (T. Duffy & Cunningham, 1996, p. 180). Robots are exemplar of a mediational device that has facets of both tool and sign.

Furthermore, T. Duffy and Cunningham (1996) explain that technology can be seen as an important part of cognitive activities.

> *This view of distributed cognition significantly impacts how we think of the role of technology in education and training, the focus is not on the individual in isolation and what he or she knows, but on the activity in the environment. It is the activity – focused and contextualized- that is central... The process of construction is directed towards creating a world that makes sense to us, that is adequate for our everyday functioning (p. 188).*

A robot's role in the military is often presented as a tool to provide support to soldiers and as an effective option for substituting human presence in hostile environments (Finkelstein & Albus, 2003/2004; Lin, Bekey & Abney, 2008; Magnuson, 2009). Viewed this way, EOD robots are clearly in T. Duffy and Cunningham's description of technology as an intersubjectively understood part of the activity in an environment. By focusing on EOD personnel as *learners* and not simply operators, the role of robots as technology can support new understandings and capabilities, thus, offering a cognitive tool to support cognitive and metacognitive processes. Viewed this way, the role of the learner is an ongoing and dynamic one, and robots create new learning activities and opportunities.

This chapter's organization has been influenced by variations of social systems theory, or the basis of discovering society's social systems of communication (Viskovatoff, 1999). According to social systems theory, a system is defined by a boundary between itself and its larger situated environment, dividing it from a complex external world (Viskovatoff, 1999) Therefore, the interior of a system is a zone of reduced complexity. Communication within a system functions via group system member selection of only a limited amount of all information available outside.

Here, the EOD *microsystem* (Bronfenbrenner, 1979), or immediate workplace surroundings of the EOD individuals and their work peers, is depicted with an overview of the people, operating environment, and everyday tasks. Further, the *mesosystem*, or relations between the different microsystems, are explained through a description of the connection between EOD common school training and shared experiences beyond the workplace in the larger EOD culture and military organization.

The criterion according to which system information is selected and processed is in *meaning*. However, systems comprise both physical and observable behaviors as well as subjective and less concretely quantified internal and individual motivations, preferences, emotions, and intentions (Viskovatoff, 1999). In addition, the theoretical base of this systems approach aligns well with the traditional breakdown of topics in human-robot interaction (HRI) research, such as task, environment, and social modeling (Burke, et al, 2004).Therefore, this work attempts to begin an understanding of the meaningful communication of the EOD individuals within the larger systems of their organization, operating environments, and job-related tasks in order to illuminate the conditions and environments in which EOD human-robot interactions occur.

This discussion is presented in a way that reflects how both social constructivist and social systems theories focus on dynamic interactions that create a system of communication, social constructs, and explicit and implicit understandings of how things are. First, there is an overview of the U.S. military as an organization in a way that is relevant to EOD culture, training, and work expectations. Then, the people of EOD work are described broadly in terms of human-human and human-robot social relationships. After that, robot definitions are introduced and robots are discussed in terms of design choices and their role in EOD teams. Finally, the operating environment of EOD work is explained with an overview of tasks EODs perform and the situations in which EOD work.

THE ECOLOGICAL SYSTEM OF U.S. MILITARY EOD WORK

In the National Research Council's report (2002), a call was made for continued robotic development for ordnance disposal, as well as an increased focus on the human factors side: "Because technologies are implemented and operated by human agents and social organizations, their design and deployment must take human, social, and organizational factors into account" (p. 298). Much has been written on the topics of military cohesion, inter- and intragroup relations, and the engineering side of robot development, but relatively little has been published about the nature of EOD work, how robots are integrated into their world, and how troops work with robots. Therefore, in order to begin to understand individuals working within Explosive Ordnance Disposal, it is critical to examine the various interconnected parts of the system in order to provide a framework for inquiry at a theoretical level.

The EOD system is one of the dynamically interdependent pieces of the holistic experience viewed as an *ecological system* (Bateson, 1972; Sundstrom & Altman, 1989; Sundstrom, De Meuse, & Futrell, 1990; Murphy, 2004; von Bertalanffy, 1968) of interconnected parts. This discussion presents some background and context of EOD work via description of the organization, people, robots, operating environment, and tasks in order to present a rich description of impactful parts of U.S. military EOD systems.

Organization

This work defines an *organization* as a definable group of people with a shared history that has a culture, as well as collective values and norms (Rousseau & Cooke, 1988). It is important to distinguish *culture*, or the pattern of meanings embedded in symbols, from *social culture* which is the "economic, political, and social relations among individuals and groups" (Geertz, 1973, p. 362), although both cultural aspects of EOD life are examined here in a broad scope. If an organization as a whole has had shared experiences, a total organizational culture will exist. Similarly, if an organization has subgroups with shared experiences, many subcultures can arise.

The military consists of subgroups, units, and teams in many forms (Arrow, 2000). In lieu of attempting to scrutinize every value, symbol, artifact, and assumption made by the larger group and all subgroups in this section, *culture* is used here to explore how EOD personnel learn their appropriate individual actions within their inter- and intra-group experiences through the shared history of formal and informal training, doctrine, rituals, and practice. Therefore, this broad concept of culture is described and analyzed by examining some examples relevant to these identified aspects of culture at the organizational level and in terms of its impact to EOD personnel.

Each service branch's actual description of their own EOD forces varies little, and shares a common mission that encompasses the protection of personnel, facilities, and critical infrastructure from the hazards posed by Unexploded Ordnance (UXO) and IEDs during combat operations, in peacetime, and in foreign and domestic settings (Department of Defense, 2006). The term *UXO* also refers to U.S. and foreign chemical, biological, radiological, and nuclear (CBRN) ordnance.

Under this broad scope of potential circumstances and situations, the settings and tasks for EOD specialists vary according to mission. These technicians tactically assist other military personnel by reducing UXO and IED threats from principal lines of communication and supply routes. They are the only forces specifically trained, equipped, and tasked to remove or lessen the hazards posed by UXO and IED and to also train non-EOD personnel how to recognize potential UXO threats. They are frequently called upon to assist specialist EOD police units; they dispose of old or unstable explosives, such as ones used in mining, fireworks and ammunition. As highly trained ordnance experts, they are responsible for escorting VIPs such as diplomats and dignitaries, and sweeping VIP-traveled areas for UXO, as well as ensuring the safety of other public places during large events. Another task of EOD technicians is to conduct post-blast investigations. The EOD job responsibilities also include supporting government intelligence units and Federal agencies such as the U.S. Secret Service and the State Department.

In their effort to reduce the threat of UXO and IEDs, the use of specific EOD tools and methods to prevent detonation, or, the Render Safe Procedure (RSP), is the critical step toward the goal of creating a secure environment for military personnel and civilians. RSP is the set of actions to render safe unexploded ordnance or an improvised explosive device based on the training, experience, and situation or mission of the EOD technicians and their team, using specific technical procedures, tools and methods (Air Land Sea Application Center, 2001).

While the threat of IEDs has been growing exponentially in recent years, the number of troops who are specially trained to defeat this threat has not grown at the same rate, although there have been increased efforts within the military branches to raise awareness of EOD work as an option (D. Brown, 2000; Svan, 2008; Talton, 2008). As of 2008, there were 456 U.S. Marines with the primary military occupational specialty of EOD technician, although the stated goal was 663 with completed EOD training (Svan, 2008). Svan (2008) also reported that the rate of airmen attrition had outpaced the rate of those entering EOD training, and the U.S. Navy's 912 EOD enlisted numbers were at 86 percent, or about 152 people short of their desired numbers. Since Svan's report, there has been an increase in Navy EOD personnel to 485 officers and 1105 enlisted sailors, according to an official Navy post (Explosive Ordnance Disposal Group 1, 2013). There are currently approximately 1,800 soldiers in the Army's Explosive Ordnance Disposal units (Hall, 2011).

One way to establish common ground is to provide universal training (Mark, 1997) and formal education. The formal education EOD personnel take part in includes classroom learning with an instructor and an established body of curriculum, as well as hands-on activities. However, EOD personnel continue learning activities throughout their career, including peer-to-peer training, self-directed activities, formal military courses that are required or optional, They also received additional training to keep their knowledge current, or for advancement and further specialty certification. In this work, *formal learning* and *formal training* refers to schooling activities that reward with formal credentials, and is taught by an official military-appointed instructor. *Informal leaning* and *informal training* occur outside the scope of the formal requirements, and is, as Livingstone (2001, p. 4) explained the term, "…any activity involving the pursuit of understanding, knowledge or skill which occurs without the presence of externally imposed curricular criteria."

In other words, the basic curriculum, goals, outcomes, and method of knowledge acquisition used in informal training and learning may be determined by an individual or collectively by a group of people, and is often self-directed to some degree. However, the basic difference between formal and informal learning as it is used here is that informal learning and training take place without an institutionally recognized and appointed instructor. Throughout this paper, the term "informal learning" will refer to both self-directed informal learning and informal education/training unless otherwise specified.

In the United States military, Explosive Ordnance Disposal personnel undergo some of the most comprehensive qualification training in all of the branches' occupational specialties. All military personnel go through some form of induction training to acquire fundamental skills and receive a certain level of indoctrination by learning service norms, procedures, specialized language, and symbols (Vygotsky, 1986). This training period formally begins with Basic Combat Training (BCT), otherwise referred to as Recruit Training or colloquially known as Basic (U.S. Army, n.d.). This initial training lays a foundation of the individuals' assimilation process into the military by de-emphasizing the person as a solitary unit and emphasizing group work, progress, and shared goals (Janowitz, 1972), as well as introducing a common vocabulary and set of procedures for doing everyday things (e.g., folding clothes) and new things (e.g., operating semi-automatic rifles).

At this point, a new recruit's success is not based on prior academic achievement or socio-economic status. Training may occasionally take the form of coaching and focus on an individual that needs assistance with a specific skill, such as the physical requirements, but frequently a form of in-group apprenticeship is used to bootstrap the person's ability to achieve. Therefore, comradeship is built among people of diverse backgrounds and the person becomes part of a greater whole.

After choosing to commit to EOD work, on average, in all service branches of the U.S. military, EOD technicians spend 10 months in job training at various locations depending on requirements that are branch-specific, such as the Navy dive school and parachute jump training. Navy EOD specialists participate in an approximately year-long odyssey with weeks of academic and physical preparation work, Basic EOD Diver Training, 42 weeks of Basic EOD Training, three weeks of EOD Tactical Training and three weeks of U.S. Army Jump School.

However, all four branches at some point funnel through basic EOD training at Eglin Air Force Base (AFB), Florida (Cooper, 2011). In 1999, the Naval School Explosive Ordnance Disposal (NAVSCOLEOD)—Navy-managed command staffed by members of all military branches—centralized the basic EOD training at Eglin AFB. "The Schoolhouse," as EOD personnel sometimes refer to the school at Eglin, trains about 800 students each year, according to the official Web site (Naval Explosive Ordnance School, 2011, para. 5). At Fort A.P. Hill in Virginia, there is a new training ground for the Army and other branches of the military: a 2,700-acre Explosive Ordnance Disposal range (Dennen, 2011), further expanding EOD resources while centralizing additional training options.

It is interesting to note that currently EOD students work hands-on with robots during only a small part of the official EOD student training program. Recently, virtual video game-based platforms have been incorporated into training (Robillard, 2011), using the same joystick and controls that a fielded robot has, but via a virtual environment to facilitate learning how to assemble the robot and maneuver it in different situations.

In all arms of the military services, EOD training continues throughout their careers. Personnel may spend their downtime practicing with robots in homemade obstacle courses, reading and learning from incidence reports, and participating in Team Leader-initiated exercises. In addition, they take part in specialized training courses like Mission Rehearsal Exercises (MRX), Global Anti-Terrorism Operational Readiness (GATOR), and Team

Leader certification training (Riemer, 2008; Bailey, 2011). Formal continuing education may also include advanced foreign language studies, advanced individual weapons training, combat life-saving medical skills, intrateam communications capabilities and training specific to urban or other environments.

Even with an EOD school attrition rate of approximately 50 percent across service branches (Lamance, 2010; Cooper, 2011) the visibility of EOD work as a potential career track has increased due to a rising public awareness in popular culture through movies such as *The Hurt Locker* (Bigelow, 2008; Cooper, 2011; Vowell, 2013) and almost daily worldwide news reports of IED incidences. Because of the surge in international IED activity and the need for a steady supply of EOD personnel despite the high attrition rate, the very structure of training and even EOD teams is evolving.

In order to combat the high attrition rate of EOD school completion, in 2011 the Air Force initiated a 20-day "screening course" (Kelsey, 2011) to prepare students before getting to Eglin. Another strategy used to supply demand for qualified EOD personnel is experimenting with different sized teams and lowering the required age for Army troops entering EOD training (Spencer, 2011). As Spencer (2011) points out in her article, these organizational strategies have received critical reviews from some EOD personnel. For example, it is possible that larger teams will be an impediment to bonding and communication, although there is a potential advantage of more individual perspectives in such dangerous tasks as EOD work. Similarly, Spencer points out criticisms of the lowered age requirements, most notably in the Army where qualified 18 year-olds can now begin EOD training.

In 2002, Lt. Col. John Stefanovich warned that qualified EOD personnel are not an easily created commodity with these words:

> *Three lessons are evident from the observations made of EOD operations in Afghanistan: A well-trained EOD soldier is more important to success than any EOD equipment. The quality of an EOD soldier is more important than*

the quantity of EOD soldiers. Competent EOD forces cannot be mass-produced after a crisis occurs.

Although younger team members may be eager to sign up for schooling, it is too early to see if the lowered age significantly affects attrition rate or long-term overall team dynamics.

The relatively low numbers of qualified EOD technicians within the military branches has helped to create a very strong subculture of specialization, experience, cohesion and in-group solidarity (Blankenship, 2011; Kirke, 2009; Yarbrough, 2008). As stated previously, these specialists have the unique position within the military where they are required to work and communicate as teams for decision-making, as opposed to the common military strict hierarchical structure where team members may have little input on a leader's chosen course of action.

EOD is also one of the few jobs where the senior members take some of the more physical risks than junior team members, and this dynamic allows the trainees to learn from the Team Leader's experience. EOD personnel are encouraged to share information through ongoing team communication (Department of Defense, 2006), where the dynamic intergroup communication critically affects the decision-making processes and therefore, mission outcomes. Written communications and reports are also used to gather intelligence, document mission findings for analysis, and inform future training scenarios (Department of Defense, 2006).

It is important to consider the significant function of fraternity among EOD members when considering the possible human emotional connection to EOD robots as the human-robot interactions evolve and robot designs change. EOD specialists can form interpersonal and intragroup bonds through common training, shared experiences and strong organizational ties. The Commander's Message of a recent issue of the *Newsletter of the*

National EOD Association (Jiminez, 2011) is a formalized example acknowledging and describing the close interpersonal associations created via EOD shared experiences:

> *Our members are our strength. They are the ones who joined together to form our Association. They are the ones who served in EOD throughout the world to make it a safer place for others and to enable those engaged in combat operations. They are the ones who provide the stories and pictures we cherish. They are the ones who gather from time to time with a feeling that they have never been apart--though years may have passed. They are the ones who, although they have never met before, feel a common bond when they meet. A bond forged in shared training, experiences, and danger. As our older members pass on--we honor them. To our current members - we offer our support and our thanks for their willingness to share in the work of the Association. To our new members, we offer a hearty welcome and our hope that their membership will be a rewarding experience. (p. 1)*

This fraternal organization newsletter introduction demonstrates the officer's way of building vertical cohesion within the EOD group by promoting peer bonding via supervisor support (Siebold, 2007). The statement is also gracefully inclusive of new members to the group, as well as veterans.

The "EOD Prayer" (Schott, 2011) written by Reverend Carl Bergstrom and commonly included in official EOD professional websites such as the National EOD Association (http://www.nateoda.org/) includes the phrase, "Grant that in the EOD Family there may be unity of spirit for the well being of all." Regardless of individual religious affiliation, the sentiment appeals to the ethos and pathos of EOD work as a shared, family-type experience with the common goal of safe and healthy welfare for everyone in the circle of EOD work.

There are also a number of observable concrete examples, or artifacts, of collaborative EOD social exchanges that are actively intended to foster intergroup relationships (Gergen, 1985). Continued community building across geographic locations and over time is facilitated by the numerous online EOD personnel social groups mediated through sites like Facebook, LinkedIn, personal blogs and bulletin boards. Sometimes the groups are established as the online face of specific battalions or associated with a military branch official website, such as the 3d Explosive Ordnance Disposal (EOD) Battalion (Bn)

Facebook page (n.d.; https://www.facebook.com/pages/3d-Explosive-Ordnance-Disposal-EOD-Battalion/183756438317677), which is administered by 3d EOD Bn staff.

Typical posts to battalion-, platoon-, or company-specific Facebook sites include photos of graduation ceremonies from EOD training and pictures of deployed members, family-oriented event announcements for relatives and friends of serving EOD members, and platoon or company reunion announcements. In addition, notices of injury and death of EOD personnel, current and retired are frequently written and posted in a newspaper-like obituary style with details of the individual's military career, personal life, and cause of death. Individuals have also set up informal online social spaces not directly affiliated with the military, and they have wider membership parameters. One example is LinkedIn's professional networking groups that allow, with moderator approval, any personnel with EOD experience to join, re-connect, and discuss military and civilian career opportunities around the world.

Another facet of EOD culture that cannot be overlooked because of its significance in building community among military EOD personnel is the EOD Memorial Foundation. The current iteration of the main physical EOD Memorial is in Eglin AFB, across from the main EOD building. All technician or officer graduates of an approved EOD School who have died on active duty related to an EOD mission or duties since World War II are eligible to have their name included on this memorial wall (EOD Memorial Foundation, n.d., 2009, n.d.). Subgroups of branches and companies sometimes have their own memorial walls, including very personal artifacts like ID tags (Choate, 2011), photos, and biographies.

These memorials are meaningful reminders for the EOD groups that aid the understanding of group history by keeping the fallen group members significant to the living and evoking appreciation and understanding for the personal sacrifices of the subgroups (e.g., Marine EOD) and groups (e.g., EOD personnel, military, American). Master Gunnery Sgt. Michael C. Sharp indicated the meaning of the wall in very plain language, "I believe the wall is a statement that the EOD community is small and the members of that community will always do our best to represent and honor our brothers and sisters in the field" (Choate, 2011).

The online presence of the Foundation contains EOD news, obituaries, and a storefront for merchandise. In addition, a database of all fallen EOD personnel of the four military branches is accessible. The linked names of the deceased reveal poignant messages from friends and loved ones. The site also hosts information about the EOD Memorial Scholarship Fund, explaining, "Applicants must be the child, stepchild, spouse, or grandchild, or other DOD recognized dependent of a graduate of NAVSCOLEOD" (EOD Memorial Foundation, 2011, para. 11). Again, this is a formal demonstration of inclusion of EOD personnel families into the larger group membership.

People

Recently, Kolb (2012) conducted research specifically examining the dynamics between humans and robots that work together in a high-stress military combat environment. Based on the results of a Web-based survey completed by 746 (soldier) participants, Kolb compared and contrasted human-robot bonds to human-to-human bonds that are formed under the same stressful combat conditions. Among other findings, Kolb came to the conclusions that (1) the findings did not prove conclusively that working with robots in combat contexts increases bonds between humans and robots, but the high stress circumstances *may* contribute to the initial formation of bonds, and (2) the idea of *emotional attachment* of humans to robots in military contexts was not proven in this study. However, Kolb also acknowledges that the idea of human-robot attachment in this sort of military human-robot scenario "could change in the future as robotic development advances" (2012, p. 80). His work measures feedback from soldiers in a recent timeframe, but attachment measures have a long-term component that needs to be studied further.

There has been promising research on the development and uses for human-robot socialness, conducted with a spectrum of robots that vary in intelligence, behaviors, appearance, abilities, and autonomy and studied in a variety of contexts (Breazeal & Scassalleti, 1999; Breazeal, 2003; Fincannon, Barnes, Murphy, & Riddle, 2004; Fong, Nourbakhsh, & Dautenhahn, 2003; Fussell, Kiesler, Setlock, & Yew, 2008; Yanco & Drury, 2004). One aspect of robot socialness— and the closely tied concept of object athropomorphication— very relevant to the current use contexts of EOD robots is examining whether or not the everyday human-robot interactions may influence operator decision-making, such as when a robot is put into a dangerous situation by the user or by the task. Fussel, Kiesler, Setlock, and Yew's (2008) research demonstrated people were more likely to anthropomorphize robots they interact with than robots in general. Chandler and Shwartz (2010) posit some aspects of anthropormorphication of product design can have positive results, such as the owners' increased effort to maintain the object. However, Chandler and Schwartz' also explain that in a social system people are disinclined to replace close others, and their findings suggest that the same averse feelings are true for replacing anthropomorphized possessions. Social norms and personal attachment are two factors that contribute to influencing this replacement hesitancy (Heider, 1958).

Apart from anthropormorphication, issues that complicate the human factors and robot design, interaction, and familiarity with a robot may still trigger operator empathy toward the robot, as demonstrated in an experiment using the zoomorphic robot Pleo, (Rosenthal-von der Pütten, Krämer, Hoffmann, Sobieraj, & Eimler, 2012) in video stimulus. Study participants interacted with the dinosaur robot Pleo prior to watching video of the robot either (1) tortured or (2) in a normal, untortured context. Findings showed physiological arousal measured during both video scenarios was higher for participants who had interacted with Pleo prior to watching the videos. Previous human-robot studies demonstrated people usually do not acknowledge that they see robots as social beings

(Reeves & Nass, 1996; Carpenter, Davis, Erwin-Stewart, & Vye, 2008; Carpenter, Eliot, & Schultheis, 2006; Nass & Moon, 2000). Yet with Pleo, the participants also confessed to having negative feelings when the somewhat animal-like robot was tortured (2012).

Another interesting piece of the Rosenthal-von der Pütten, et al study (2012) is that participant *loneliness* affected their level of emotions and empathy with the robot Pleo. Lonely people may employ a variety of behaviors to mitigate the pain of social isolation from others. Epley, Akalis, Waytz, and Cacciopo (2008) and Epley, Waytz, Akalis, and Caciappo (2008) have suggested that one way lonely people may attempt to alleviate a human-human disconnect is by anthropomorphizing nonhuman agents such as "mechanical devices" (p. 114). This vein of inquiry leads down a path of possible scenarios for military personnel such as EODs who are separated from their homes and families during deployment and missions, and merits further study into the impact of loneliness, the humanization of familiar robots, and its impact on decision-making.

However, in the Rosenthal-von der Pütten, et al. study (2012), the people who interacted with the robot prior to watching the video stimulus had 10 minutes to become familiar with Pleo, an introductory period of time not conducive to forming strong bonds of attachment. One of the basic premises of Bowlby's (1973, 1980, and 1982) attachment theory is that physical or psychological threats (e.g., assessing UXO, the injury or death of a team member) automatically activates the attachment system—a system whose goal is maintenance of proximity to supportive others. Therefore, understanding when robots become regarded as "supportive others" to users is part of the key to understanding how the dynamic interactions between human and robot need to be balanced in order to create the most effective and safe HRI scenario. In addition, understanding the details of what situations, robot design, operator personality, training and other factors contribute to the formation of the *supportive other* role also implies it will be possible to manipulate these specific factors. In turn, purposefully changing these variables leads to the opportunity of enhancing or mitigating the attachment bond of human operators toward robots in a way best suited toward safely achieving missions and tasks.

As explained throughout this chapter, individuals within the EOD community must have the ability to work as part of a team, have effective interpersonal communication skills, be able to withstand prolonged academic demands and physical rigor, make quick decisions based on RSP and, on occasion, act *in situ* with little outside-group guidance. In other words, the people within the EOD groups operate effectively under stress and are experts in a range of topics, from engineering-oriented to inter- and intrapersonal skills and physical prowess. Understanding what type of person succeeds at such a multidimensional and demanding job will give richer insights toward determining efficient task-oriented robot design, especially when designing a semiautonomous robot that functions as an effective tool for team collaboration without user distraction or impediment to goals.

In a 1985 longitudinal study, Hogan and Hogan (1989) identified consistent personality characteristics among Navy divers as well as Army and Navy EOD apprentices and students who successfully completed training, including traits such as being well-adjusted, spontaneous, physically self-confident, open to new experiences, rowdiness, technically oriented, and introverted. However, it appeared once trainees were incorporated into the fleet, they became increasingly cautious and conforming when compared to the study's EOD students. Given these changes in personality once situations and experiences changed from classroom to fleet life, it is a reasonable hypothesis that these traits, although consistent, also evolve as the EOD personnel's knowledge changes over time from novice to expert.

More recent studies about EOD trainees and personnel produced statistically significant findings that supported the hypotheses that people attracted to and successful in EOD work have similar learning style preferences and intelligences (Bates, 2002; Bundy & Sims, 2007). Yet data also suggests that variations existed both within and between an assortment of demographics such as age, rank, or armed forces branch. Again, additional research still needs to continue in the field with EOD personnel in order to account for situational conditions and stressors beyond the classroom or training context.

Like any profession, EOD work as a whole is composed of a collection of individuals with a wide variety of ages, formal education, career goals, personal preferences, personalities, physical differences, and levels of technology acceptance. In this work, it is relevant to discuss emotions as a means to discover patterns from the group in personality type, artifact interpretation, situations, and specific goals as a way to predict or manipulate emotion through robot design (Lazarus, 1993; Norman, 1988; Rafaeli & Vilnai-Yavetz, 2004) and not an attempt to categorize the illogical or irrational. Studying the relationship of emotion to decision-making specifically in EOD human-robot scenarios also makes it possible to begin developing a fuller understanding of the impact of robot design on the overall mission. In a world of semiautonomous robots, human decision-making is still a critical part of achieving mission goals. In current EOD team models—typically consisting of three to eight members, depending on service branch and mission type—potentially adding collaborative humanoid semiautonomous robots will be a valuable tool and one that can create a new social role within the group.

In addition to the role of the robot, the roles users have working with robots and the impact these relationships have on user perceptions of working with robots in teams is important when discussing the dynamic of human and robot in EOD work. Scholtz (2002 & 2003) defined several roles users may have working with semiautonomous robots in team situations, including supervisor, operator, mechanic, peer, and bystander.

In today's EOD work with current robot models, the EOD users role is likely to encompass aspects of several or all of these interactions, as Scholtz (2002 & 2003) originally defined them, including monitoring the overall use situation, operating, commanding, or maintaining the robot. As Scholtz stated, the overlap of some of these interactions may at times be blurred (2003). These roles, as Scholtz noted, have different interaction dimensions to them that affect the user in terms of goals, intentions, actions, perception, and evaluation when working with robots.

When discussing collaborative work environments and emotions, there are several relevant emotion-based concepts that need to be addressed: (1) bonding, (2) cohesion, (3) trust, and (4) attachment. Human-human *bonding* is more than merely liking another person. In this work, it refers to an interpersonal relationship developed over time. At this stage of technological development, robots cannot return affection, affinity, empathy, or other complex human emotions. Therefore, any potential model of bonding in this discussion will refer to a one-way model, or human-to-robot. The process of human-human bonding can occur over social and task-related components (Eisenberg, 2007), including task cohesiveness, which refers to the degree to which group members share collective goals and labor together to meet these goals.

Group *cohesion*—the linking of people via bonding in a group—incorporates the social and task-oriented factors of bonding with the addition of a perceived group unity and emotional aspect (Forsyth, 2010; Johns, et al.,1984). In group cohesiveness, the social facet is based on the relationship that members feel to other group members and to their group as a whole. This type of cohesivesness can be both a formal and informal type of social structure (Kirke, 2009). Group cohesiveness is *formal* in that it exists within the more global military hierarchy as a specific subgroup: Explosive Ordnance Disposal.

This structure exists also *informally* as a group of ideas and norms within EOD that may not be explicitly named, but that form a set of conventions and expectations for behavior and actions. In a relevant example for EOD work, Wong et al. (2003), when discussing social cohesion, cite shared combat trauma as a strong condition for bonding between soldiers. A system of robust informal bonds between group members contributes to the overall cohesion, as does the more formal convention of a clearly structured set of goals

(Kirke, 2009). It is important to note that cohesiveness is not something that is constant, but is dynamic and an ongoing negotiation between individuals within a group and is largely dependent on *operating structure*, or the shared cooperation of a task, goal or mission (Kirke, 2009).

Trust is also an essential requirement as part of a functional relationship between humans to ensure that collective goals and outcomes will be effectively worked on together. Hancock, Billings, and Schaefer (2011) define trust as “the reliance by an agent that actions prejudicial to their well-being will not be undertaken by influential others” (p. 24). Using this definition, a human’s trust in a robot’s behavior and reliability is necessary for effective human-robot interaction to transpire. Barber (1983) claimed that trust results from learning in a social system and is used by an individual to manage their expectations regarding relationships and social environment. Therefore, trust is a part of all social relationships and is used as a means of prediction for the individual. In the case of EOD or similar potentially life-threatening human-robot work, issues associated with operator trust toward the robot are of particular concern when a person expects to rely on a robot for the safety and welfare of themselves and others. Furthermore, trust is also a critical factor in human relationships because it influences interaction results via attitudes, behaviors, and perceptions (Dirks & Ferrin, 2001).

One relationship model between humans and nonhumans that can be looked to for possible insights to human-robot relationships is that of human-animal teamwork. In addition to human-human collaboration, a military setting is not an unusual place for human-animal joint effort. In fact, there are a reported 2,700 dogs serving with the U.S. military worldwide, with 600 of those active in designated war zones (Rizzo, 2012). The significance of human-animal bonding to the situation of EOD-robot work is twofold:

(1) Research suggests that human trust and bonding with robots may have some emotional parallels to human-animal bonds (Billings et al., 2012).

(2) How the military classifies and regards working animals is a potential paradigm for how robots are classified now and in the future. This official classification, in turn, affects troops by explicitly positioning the robots' social role within teams.

Human-animal partnerships are unique and can benefit people emotionally, physically, and cognitively (Levy, 2007; Wilson, 1994). Although military canines, or Military Working Dogs (MWD), work with their soldier handlers closely, the Defense Department currently classifies these dogs as "equipment" (Cullins, 2011; Rizzo, 2012). This classification comes from the necessary defaulting between the only two choices the military currently assigns assets: humanpower or equipment (Cullins, 2011).

However, soldiers forge strong emotional bonds with these canines that act as part of their team regardless of the "equipment" classification. In World War II, via the Dogs for Defense program, troops worked with civilian pets that were volunteered by their owners for military service, and then subsequently trained and integrated into military specialties such as explosives detection. One example from the WWII era of human-MWD bonding is exemplified in a letter written by Marine PFC Wachtsletter to the dog's owners, to inform them the dog had died in service (National Public Radio, 2012). Wachtsletter wrote of Tubby, the Working Military Dog, "…He behaved like a true Marine at all times and didn't even whimper when he died. We've buried him at the Marine Cemetery along with the other real heroes of this campaign…He has a cross with his name and rank. He's a corporal."

Dogs for Defense ended in 1945 because of the many logistical problems involved with borrowing civilian dogs and retraining them to be integrated back into their original families, post-specialized military canine training. However, MWD owned completely by the military are not less likely to bond with their human trainers and handlers. Lackland Air Force Base spokesperson Gerry Proctor (Rizzo, 2012, para. 18) states, "A handler would never speak of their dog as a piece of equipment. The dog is their partner. You can walk away from a damaged tank, but not your dog. Never."

Currently, robots are classified as equipment in the U.S. military (*Robotic Systems Joint Project Office: Unmanned Ground Systems Roadmap Addendum*, 2012). Because of the strong bonds soldiers forge with these animals, there is a passionate MWD advocacy movement proposing to change the military classification for working canines from *equipment* to *manpower* (or a third, as yet undesignated category) in order to initiate and clarify policies for prolonged care and maintenance of the dogs after retirement (Cullins, 2011; Rizzo, 2012).

Some robot designs already being tested or used for military purposes resemble animals in appearance or behavior, such as the four-legged BigDog, developed by Boston Dynamics. Research using zoomorphic robots has demonstrated that in some conditions and circumstances, imbuing robots with animal-like characteristics may support effective human-robot interactions (Arkin, 2005), and using a robot with animal-like traits can also affect human-operator perceptions about the robot's intelligence and abilities (Bartneck, Reichenbach, & Carpenter, 2006; Bartneck, Reichenbach, & Carpenter, 2008). Therefore, there is an interesting set of potential emotional dilemmas for troops working closely with these robots, and projecting any sort of trust, bonding, or attachment with an inorganic thing that can be destroyed, put in danger, replaced, left behind, abandoned, or treated as any other piece of military equipment.

Another important aspect of EOD work is *stress*, or any variable in that disrupts the normal functioning of an individual. Stokes and Kite (2001) explain there are two psychological models of stress typically addressed: stimulus-based and response-based. However, both of these models are largely based on environmental stimuli and ignore individual traits and experiences, or evaluate circumstances, situation, or context as well as neglecting emotional components. Therefore, Stokes and Kite maintain there are no absolute psychological stressors—what may cause stress for one individual may have relatively little emotional or behavioral impact on another individual. Better suited to this study is the concept of the *transactional model*, which posits stress is a dynamic interaction between an individual and their environment, with an emphasis on the role of the individual's situation appraisal in shaping their responses (Lazarus, 1966; Lazarus & Folkman, 1984; McGrath, 1976). In Stokes and Kite's explanation of the transactional approach, stress is defined as, "…the result of a mismatch between individuals' perceptions of the demands of the task or situation and their perceptions of the resources for coping with them." (p. 116). To an outsider looking in, the nature of EOD work—or any military work—may be considered stressful for many reasons.

Regardless of the cause, stress may affect many crucial tasks and behaviors part of EOD work such as attentional processing, task management, working memory, and decision-making (Staal, 2004). However, the focus of this research is not to claim any specific tasks, situation, or environments are stressors for EOD personnel. Rather, this work explores the human-robot relationship to discover if this dynamic is a set of variables that introduces stressors and, if so, begin to define and explain what and how aspects of human-robot interaction cause stress to the EOD operator.

Examining the ecology of EOD personnel as individuals is the basis for measuring, predicting, and understanding the performance of team members. Therefore, it is critical to explore the impact of human-robot relationships to determine where social interaction is needed or expected in robot design to improve team performance and how robots work with individuals within teams.

Robots

Works of fiction, folk storytelling, and popular culture have influenced people's expectations of robot appearance, behavior, and purpose (Kaplan, 2004). Even the word *robot* has its common roots in fiction. The Czech word *robota* was the inspiration for author Karel Capek's (1920) term for the humanlike artificial agents that make up some of the key characters in his story *RUR (Rossum's Universal Robots)*. In *RUR*, Capek's worker robots were portrayed as tireless and uncomplaining workers until they were imbued with emotion; once emotion was installed in Kapek's robots an android uprising killed the humans and robots ruled the world.

Fictional concepts about artificial human life have been omnipresent around the world for thousands of years via mythology and folklore, such as Prometheus' clay men (Hyginus, c 900/1960), Hephaestus' creation of Pandora (idem), Pygmalion's Galatea statue come to life (Ovid, A.D. 8/2009), and the golems of Jewish storytelling (Goldsmith, 1981; Idel, 1990). Recent popular culture stories purposefully pull just enough from technology and the complications of possible results to make a titillating character or story plot. For every lovable robot portrayed in films such as *Star Wars* (Kurtz & Lucas, 1977) or *Wall-E* (Morris & Stanton, 2008), there are many tales told that focus on dangerous robots such as Gort from *The Day The Earth Stood Still* (Blaustein & Wise, 1951), *Blade Runner's* replicant-robot assassins (Scott, 1982), and the near-indestructable *Terminator* (Hurd & Cameron, 1984).

Film, television, books, and magazines are critical pieces of society where myth-making and meaning–making emerge and combine with what people know from real experiences. Contemporary anxieties associated with robots are bound up with cautionary stories about humans overstepping their abilities when creating artificial life, such as Shelly's (1994) Frankenstein creature or the robot child in the film *AI* (Kennedy, Spielberg, & Curtis, 2001). These themes and metaphors in turn contribute to contemporary attitudes toward scientific advancements (Nerlich, et al. 2001).

The term *robot* has many interpretations, but in this chapter, the term *robot* is based on B. Duffy's description (2000) of the physical element of robots as the presence of a mechanical system in our environment or social space, including Murphy's clarification that robots are embodied and can therefore interact in the physical world (2000). Robots with humanlike physical and/or behavioral characteristics are commonly referred to as *humanoid,* *humanlike,* or *android*, and those terms commonly evoke images of highly anthropomorphic robots, when in fact, there are robots with a spectrum of humanlike characteristics that can be categorized with those terms.

Using semiautonomous robots in dangerous situations offers some obvious advantages: (1) minimization of the risk to human life with robots taking over dangerous tasks previously done by humans, (2) a robot's imperviousness to chemical or biological weapons, (3) its endurance, agility, strength; and (4) the ability to program robots with limited "emotions" that might influence user situation assessment.

As stated in Chapter 1, using robots with some humanlike features may have advantages in specific terrains or for specific tasks or human-robot interactions. However, there are also ethical considerations in using these robots. Related to the idea of human-human emotional bonding is the concept of anthropomorphizing robots, thus thrusting robots into a role that straddles human-human and human-robot relationships. For example, many people name their cars, boats, dolls, or even weapons, such as rifles and tanks (Battarbee & Matalmaki, 2004). The findings of Sung, Guo, Grinter and Christensen (2007) showed just over two-thirds of their study participants named their Roomba, a vacuum robot used in the home, and many referred to the robot as "he" or "she." Early work in human-computer interaction (Reeves & Nass, 1996; Nass & Moon, 2000) found that people ascribe human qualities like gender and politeness to even disembodied machines.

The research of Bowlby (1973; 1980; 1982) supports the theory that the more time a person spends in close proximity to another person, emotional bonds will be strengthened. Thus, it is a useful course of inquiry to begin to explore how people interact with robots used every day in order to determine if human-robot bonds form in any way that resembles human-human bonds. Despite the different technologies studied in these examples, the common foundation is that user familiarity leads to greater acceptance of a technology and its perceived usability.

Anthropomorphism describes the human tendency to instill the real or imagined behavior of nonhuman agents with humanlike characteristics, agency, intentions, or emotions. It is necessary to be clear that the human tendency to attribute humanlike qualities—or the *anthropomorphism*—of robots occurs when interpreting a variety of cues, and does not rely on appearance alone. Examples of inanimate object cues people use to anthropomorphize robots or other inanimate objects include objects responding to or using natural language cues; gestures or movement interpreted as having intentionality (Breazeal & Scassellati, 1999; Norman, 2005); or having parts that resemble or work like a human body (Mori, 1970; DiSalvo, Gemperle, Forlizzi, & Kiesler, 2002). Nass and Moon (2000) have stated that even a minimal amount of humanlike cues can evoke a wide range of strong attitudinal and behavioral consequences in individuals. Because humans use their models of human-human interaction to make sense of robot interactions, they may overestimate robot intelligence (Lee, Kiesler, Lau, & Chiu, 2005) from minimal social signals, possibly affecting human-robot team or collaborative interactions.

Dunn (1995) uses the term *morphology* to describe the phenomenon of a user's perception when "the degree to which an object…measures up to their perception of living forms, based on their own body-centric cognitive constructs about what constitutes the parts of a living form." Dunn explains the important concept of *morphology* as the assumption that people project their own meaning and experience of embodiment onto the patterns implied by the stimulus. He further states that people instill these constructs with "affection and expectation and endow them with attitudes and emotions….They react to, describe and remember them almost as they might other people."

Other recent studies (Carpenter, et al, 2008; Carpenter, Eliot, & Schultheis, 2006) have indicated user expectations and preferences for robot appearance correspond with Dunn's explanation, with users matching expected robot capabilities and behaviors to the outward anthropomorphic design affordances of robots used as stimulus. The same studies indicate people also attribute agency and emotion to humanoid robots used as stimulus, even describing them in human terms. In other words, if a robot has something the user believes resembles an animal-like quadruped morphology, users (a) expect the legs to function similarly to a four-legged animal and (b) these design characteristics may trigger emotional associations to the robot in a way similar to that of user-animal. In this example, the legs are an affordance and the user is matching their own mental construct of animal-like legs and their function to that of the robot's legs.

Robot forms, or embodiment, have been categorized into four appearance-based groups (Fong et al., 2003) (1) anthropomorphic (humanlike), (2) zoomorphic (animal-like), (3) caricatured (exaggerated qualities), or (4) functional (design based on its intended tasks). Although other social cues besides appearance impact the human tendency to anthropomorphize (or not) a robot, a degree of humanlikeness in robotic form affects how people interact with robots, and can establish social expectations about interactions and abilities (Carpenter et al., 2008, 2009; Fong et al., 2003). Experimental research in human-robot collaborative team interactions has demonstrated that in collaborative situations, not all robots are treated the same by human partners (Groom, Takayama, Ochi, & Nass, 2009; Hinds, Roberts, & Jones, 2004).

For example, highly anthropomorphic robots are praised more and punished less (Bartneck, Reichenbach, & Carpenter, 2006) than other mechanical representations, such as less humanlike robots. However, experiments and *in situ* observations of human-robot teams will need to be conducted over extended periods to see if human attitudes and expectations evolve in any way toward humanoid robots used everyday in collaborative situations, and then determine what level of robot anthropomorphism facilitates EOD work instead of impeding it.

EOD robots already imitate human behaviors just by the nature of their tasks, even when they are teleoperated field machines with low-level intelligence. As critical components of the EOD toolkit, robots stand in for personnel to perform dangerous duties and help complete missions. There is anecdotal evidence that supports the idea that in some cases, EOD personnel do attribute organic traits to these machines (Barylick, 2006; Garreau, 2007; Kelly & Johnson, 2012), and describe their relationship to the robot in terms of emotional attachment, sometimes naming the robots, and treating the robot as a pet, teammate, or as an extension of themselves.

It is not surprising robots are referred to as living things; sometimes it is because people use human-human interaction cues mapped onto human-robot interaction, and other times it is because robots seem to exist in an as yet undefined social space. How EOD robots are presented to personnel is another topic worth examining because it bootstraps the concepts of functions and roles on the team or within the unit. In a 2010, U.S. Army recruitment video, robots are positioned as team members. “We run in three-man teams. [*Gestures at QinetiQ North America’s TALON robot*]. This is our fourth member. We can send this guy out and he does the dangerous stuff for us,” Sgt. Dean stated in the Army video. Later, in the same video, Staff Sgt. Mitchell proclaims, “Our robot driver is Dean. So we just call this robot mini-Dean.” Whether these are scripted comments or genuine remarks are less important than the fact that this robot is referred to as a team *member* and an extension of the user (Sgt. Dean).

This scenario may influence personnel about how to interact with a robot—primarily in a social or interdependent manner—as opposed to positioning it as an inanimate tool like a tank or rifle. From the Armed Forces projected standpoint, the robot stands in for the EOD personnel as a sort of troop doppelganger or an extension of their physical self. Consistent messages reported from EOD people working with robots and aggregated by Roderick (2010) demonstrate that human operators currently trust EOD machinelike robots, facilitating decisions about sending in robots in lieu of humans in dangerous situations.

The military's message to the public that these robots act as anthropomorphic stand-ins to save human lives has many latent implications in the interpretations of this representation of technology. It is true that robots are a valuable tool to EOD personnel and save lives by acting out tasks in dangerous scenarios. However, the inaccurate representation of the robots as possessing characteristics such as humanlike membership in the team positions the robots in a social context that arguably simultaneously legitimizes and minimizes the use of this type of technology in warfare by imbuing it with value as more than a tool. Therefore, this presentation could make the idea of this technology more palatable for potential recruits as well as to other audiences, reassuring them that robots seamlessly mitigate risk to human life and do so in an understandable, humanlike way (Roderick, 2010).

A humanoid robot may be extremely effective at specific tasks, but still elicit spontaneous emotions in the users. Emotions are a significant component of a functioning human and are tied closely to our actions and reactions. How people appraise situations and others results in distress, relief, anticipation, hope, frustration, pride, dislike, affection, contempt, surprise, fear, and an infinite list of fluctuating states humans use for self-reflection, use to act in circumstances, and employ to assess people and things in the world.

Mori (1970/2012) developed a graphical illustration to accompany his theory about human emotions and humanlike robots. The word *valley* refers to a dip in the y-axis (familiarity) of Mori's proposed graph showing the positivity of human reaction as a function of a robot's lifelikeness. Mori's theory states that the more humanlike a robot is in its appearance and movement, the more positive and empathetic a human being's emotional response to the robot will be. However, a point on the x-axis (humanlikeness) of the graph that occurs when the entity is almost indistinguishable from a live human pushes the human response to strong repulsion.

Mori posits that the reverse holds true; as the appearance becomes less distinguishable from a human being, the emotional response becomes positive once more and approaches human-to-human empathy levels. Thus, the “dipped” area of repulsive response aroused by a robot with appearance and motion between a “maybe-human” and “perceived-human” entity is called the uncanny valley. One implication of this uncannyness is that humans may feel robots that appear too human are unsettling, perhaps because they are in an unrecognizable category of thing that resembles something organic, but clearly is not. Therefore, any initial user perception of uncannyness in a robot has the potential to distract the operator at some level.

In this early development of the field of human-robot interaction, issues of accurate user expectations of robot functionality, behavior, and response are growing increasingly more complex and raising questions of ethics and morality in relation to human-robot relationships, as well as how robots will be used in warfare and covert operations. Evolving discoveries in robotics, human emotional reactions to new technologies, and new situations and contexts for robot use create new human-robot relationships that lead to larger discussions relating to the expectations, obligations and responsibilities humans have toward machines and their uses (Brooks, 2002; Lin, Bekey, & Abney, 2008; Arkin, 2009). Therefore, individual expectations of robots are not merely the domain of the individual user, but also of society.

Dialogue has already emerged in the form of such initiatives as South Korea’s *Robot Ethics Charter,* which claims to be developing legal guidelines on how to treat robots (Yoon-Mi, 2007). In addition, there are projects like the *Euron Roboethics Roadmap* (Veruggio, 2006), developed by scientists from the European robotics community who are responding to the perceived need for discussion and development of an ethical framework that may eventually serve as a useful guideline for the design, manufacturing, and use of robots.

Operating Environment

Because the nature of military EOD work encompasses foreign and domestic locations and a variety of duties such as VIP protection and unexploded ordnance detection and defusion, it is impossible to say what a “typical” physical work setting or location is in this profession. For those reasons, in this work, the term *operating environment* refers to an overview of the situations people are in, rather than focusing on one geographical site or specific incident type.

The term *field robot* also has different definitions, but this chapter will build on Jones & Hinds’ use (2002) by referring to a robotic mobile platform that is semiautonomous and teleoperated, often used in a dynamic operating environment. The primary user extends their own abilities to sense and maneuver by operating the robots at a physical distance. Thus, field robots principally interact with the operator from a distance, making the humans, in some ways, spectators.

Murphy (2004) specifically referred to the robots used in the contexts of space exploration, humanitarian rescue efforts and military efforts as *field applications*. Using this term, field application domains have two pertinent characteristics: first, these robots are subject to unstable environmental effects that can hinder the robots’ stability and communication resources. For example, in a field situation, a robot may flip over in a ravine or lose radio communication with the operator in rocky terrain. The second characteristic Murphy assigned to field application robots is their use is intended to keep a human from direct harm by operating at a physical distance from the primary user(s).

Robots used as tools on EOD missions share the same physical space as the human team members during transport and then are often the first line of contact sent out to investigate IEDs or re-locate UXO to a distance safe for personnel. In the current model of EOD work, members collaborate at a mission’s location, but may be somewhat at a distance from each other in the course of actions. For example, if a Team Leader is required to put on a bomb suit and use RSP on an IED because the work is beyond the scope of the robot, the Team Leader is then in communication with other team members from a geographical distance and technology provides the mediated communication for team work.

Situational awareness is a significant component of teleoperation tasks. A common problem with field robots is user reliance on video feeds and a lack of direct interaction with the environment that hinder the operator's accurate understanding of robot location and stability (Casper & Murphy, 2003; Darken, Kempster, & Peterson, 2001; Lewis, Wang, & Hughes, 2007; Woods, Tittle, Feil, & Roesler, 2004; Scholtz, Young, Drury, & Yanco, 2004). The robot's operator must manage multiple cognitive tasks and dynamic incoming information to manipulate the robot's actions. Current EOD robot models use tracked or wheeled systems to maneuver in physical space. Finkelstein and Albus (2003/2004) reported that wheeled machines might operate on about 30 percent of the earth's land surface, while tracked vehicles can travel on about 50 percent. EOD robots are also required by their function and operating environment to move in spaces such as buildings and other human-made spaces. The advantage of using agile and stable-legged or even biped robots becomes obvious, then, with the ability to effectively work in a larger arena of surfaces and situations.

Tasks

In order to succeed at every level, EODs must be able to carry out individual tasks and *cooperative tasks*, or activity that takes the coordinated effort of multiple people in order to complete the actions. Team structure and size are dictated by official military guidelines, but that is also shaped by the nature of the work and, to some extent, the technology used, such as the robots. Team tasks differ from individual tasks in many ways, including coordination and communication between members (Nieva, Fleishman, & Reick, 1978;

Naylor & Dickenson, 1969), and the dependence of team outcomes on performance by all members (Steiner, 1972).

Because of the nature of EOD work, every situation is unique, and therefore, even when following standard Render Safe and Disposal Procedures, the team must have a level of ongoing intrapersonal planning, decision-making, and negotiation, or *conceptual tasks*. Sundstrom, De Meuse and Futrell (1990) describe military teams as "highly skilled specialist teams cooperating in brief performance events that require improvisation in unpredictable circumstances" (p. 21). This characterization appears to fit EOD teamwork in most circumstances.

The robots used by EOD teams as tools help complete joint tasks as part of the teams' everyday work and so, between training exercises, routine maintenance, and missions, for many human operators there is some level of human-robot interaction as a daily activity ranging in duration from a few minutes to many consecutive hours. However, not every team member works directly with a robot by operating it. Individual roles vary by leadership certification, as well as by specialized training and assignment. As mentioned previously, the standard number of people within each EOD team also varies for each military branch.

Using the Army's description of EOD Military Occupation Specialty (MOS) 89D EOD Specialist, specific duties are outlined at five "skill levels" (MOS 89D, n.d.). These duties are lists of *behavioral tasks*, things with physical behavior, that range from the preparation of technical intelligence and incident reports to locating buried ordnance, radiological monitoring, technical mentoring of less experienced soldiers, developing new or modifying Render Safe and Disposal Procedures when necessary, and advising commanders when UXO are within their range of operation.

Team Leader duties encompass the first four levels of responsibility as well as overseeing the team's safety and training, performing the diffusion of ordnance, deciding how to diffuse explosives and what precautions to take. They also act as a liaison between the team and commanders and their staff. Team Leaders provide direct expert advice to senior Secret Service staff during Presidential and other VIP details, and act as the team liaison with FBI, ATF, and civilian law enforcement when called to assist those agencies.

Conceptual tasks associated with EOD work, or socially interactive tasks like planning an appropriate course of action, negotiating approaches, and intragroup decision-making, however, are myriad, situated, temporally dynamic and highly context dependent (Stewart & Barrick, 2000). One way to examine the conceptual tasks of an EOD team is via *interdependence*, or the extent to which team members cooperate and work interactively toward task completion (Campion, Medsker, & Higgs, 1993). Successful EOD teams require a high level of interdependence, where individuals rely on each other for information, materials, and reciprocal participation.

It is a fair hypothesis that introducing new technology into this dynamic in the form of robots with increasingly anthropomorphic design and with an ability to perform more complex tasks, communicate at a higher level, and exchange richer information with humans, will impact the current team structure and possibly a reorganization of some behavioral tasks, if not conceptual ones. This new set of variables warrants continued research into how levels of human-robot interdependence may increase or decrease and change the current EOD team dynamic and, therefore, how it will affect implementing new training paradigms and achieving mission outcomes.

SUMMARY

This chapter introduced the theoretical concepts scaffolding the work: namely social constructivism and systems theory. Following this framework, the world of EOD personnel was explained in terms of how they are situated within the military as an organization; characteristics and shared experiences of EOD as a group; how robots are typically used in

EOD work; the nature of an EOD operating environment; and the way EOD manage cooperative, behavioral and conceptual tasks.

RESEARCH PROCEDURES AND METHODS

This study conducted exploratory research on EOD personnel human-robot interaction practices rooted in individual human perception and experience. Specifically, the researcher examined these human-robot interaction experiences with two goals in mind:

1. Describe everyday human-robot interactions of this segment of users in terms of experiences, expectations, emotions and actions.
2. Develop a holistic understanding of these users' everyday human-robot interactions.

The issues examined here have only recently emerged as an area for academic scrutiny; therefore, the nature of this work is exploratory. To address the goals of this study, the researcher developed a qualitative methods strategy appropriate for this study in order to comprehensively examine the complex set of user groups, their activities, processes, and culture, and their interrelationships.

This chapter outlines the overall research design and rationale employed in this study. It includes a discussion of the basic research design, sample selection, data collection and management methods, reliability and validity issues, data collection and analysis strategies, and ethical considerations.

RESEARCH STRATEGY AND DESIGN

The strategy described addresses the purposes of this exploratory work. Because this strategy needed to support the understanding and subsequent description of EOD personnel experiences with robots in a rich way, it needed to gather a sufficient amount of data to address the guiding research questions posed:

1. What are the activities, processes and contexts that influence or constrain everyday EOD human-robot interactions?
2. What human factors are shaping the (robotic) technology?

These questions are amenable via qualitative research methods, which focus on understanding and describing a phenomenon. Lincoln and Guba (1985) identified some tenets that scaffold qualitative research, and described these beliefs as follows, "Qualitative research assumes that there are multiple realities-that the world is not an objective thing out there but a function of personal interaction and perception. It is a highly subjective phenomenon in need of interpreting rather than measuring" (p. 17). This way of looking at research examines whole, complex systems and does not seek to reduce findings to linear, causal relationships. Patton explains the value of qualitative research methods as a way that "greater attention can be given to nuance, setting, interdependencies, complexities and context" (1990, p. 51).

Qualitative research is interested in providing detailed description about context, activities, participants, events, and processes. It is about describing the phenomenon, rather than focusing on outcomes. According to Domegan and Fleming (2007, p. 24), "Qualitative research aims to explore and discover issues about the problem on hand because very little is known about the problem." Further, Patton (1990) stressed that qualitative methods are "particularly oriented toward exploration, discovery, and inductive logic" (p. 44). Therefore, since very little is known about this specific area of research, this type of research method strategy is designed to be inductive and discover how people make sense of things and interpret the world around them.

Qualitative methods of data collection and analysis allowed the researcher to reach an in-depth understanding of the complex factors that make up EOD human-robot interactions. Strauss and Corbin (1990) characterize qualitative work as any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification (p.17). Specifically, the authors indicated that the analysis in this type of research is one that involves a "nonmathematical analytic procedure that results in findings derived from data gathered by a variety of means" (p. 18).

Qualitative research data is mediated directly by the researcher through data collection instruments. This research design employed questionnaires and semi-structured interviews of EOD personnel. Using multiple methods of data collection provided sufficient data in order to address the study's research questions.

SAMPLE SELECTION

According to Merriam (1988), the needs of qualitative research are best met by nonprobability or non-random sampling. This type of work does not attempt to find a group of representative people across a population, but rather follows an inquiry with people who have acknowledged experience and insight into a field. This study used a type of nonprobability sampling called *purposive (*or, alternately*, purposeful)* sampling.

Merriam (1988) described purposive sampling as a method "based on the assumption that one wants to discover, understand, gain insight; therefore one needs to select a sample from which one can learn the most " (p. 48). Patton (1990) explained, "The logic and power of purposeful sampling lies in selecting information-rich cases for study in-depth. Information-rich cases are those from which one can learn a great deal about issues of central importance to the research" (p. 169). Therefore, purposeful sampling contributes to credibility because participants are sought in part by the likelihood there is a shared base experience or background, and will therefore have a common understanding of truth-telling, although their individual truths may differ. In addition, because sampling aims to include "the widest possible range of information for inclusion in the thick description" (Lincoln & Guba 1985, p. 316), transferability is facilitated. Moreover, the constant comparison of data adds to credibility (Ambert et al., 1995) because the research strategies employed contribute to data accuracy.

Participants in this study had to meet several requirements in order to be involved. By establishing inclusive criteria for individual participation, the researcher maximized the opportunity to gain information relevant to the research questions. Criteria for participant inclusion included:

1. Prior or current service in a branch of the U.S. military.
2. Training to work with robots in the field.
3. Working experience with robots in a military field setting over a period of time.

In addition, potential participants were deemed ineligible if their experience with robots was limited to drones, or fully autonomous robots, or if they only had experience with robots outside a military setting. In return for participation, participants were offered $35.

The questionnaire and interview sources of data were obtained from a group of 23 EOD personnel. As an investigative study of EOD personnel-robot interaction in this domain focusing on personal experiences, the goal was to target a convenience sample of EOD personnel that were self-identified long-term semiautonomous robot users, and had specific training to work with robots. Therefore, identification of this group of participants was the result of a sample recruited in a way that targeted individuals with certain characteristics and was not intended to be random.

Closely tied to the idea of what people to sample is the size of the sample. In terms of data collection, the idea of *theoretical saturation* (Glaser & Strauss, 1967, p. 61) is the point when no additional data is found in the process and analysis can begin. As opposed to the process of data collection, the data analysis method used here (and discussed in detail later in this chapter), allowed the emergence of categories and subcategories in how the people, activities, tasks, and situations are intertwined and viewed by the participants (Stebbins, 2001).

Therefore, in qualitative work it is rare a specific number of participants are prescribed in order to produce sufficient data. A total of 23 people participated in the study and all responses were analyzed. In this study, 23 participants were determined to be a reasonable sample size because during data collection and analysis, no new information was found using the research methodology described in this chapter.

Recruiting took place over a period of seven months (March 2011 − August 2011) and occurred over the Internet and the use of a hardcopy flier. It is important to note that in order to keep the pool open to as many potential participants as possible, the recruitment materials did not specify membership in an Explosive Ordnance Disposal group as a requirement for participation. However, due to the nature of the actual practice of recruiting, the most successful method of finding people was using a snowball technique, or finding participants through other participants.

Initially, recruitment began via a volunteer source within the local EOD community. Through that entrance into the participant recruitment base, the group became unintentionally and exclusively EOD personnel. Because the goal of this study was to examine and describe human-robot phenomena in-depth, for a study of this size it was determined advantageous that this common group membership trait added a basis for acquiring a range of personal experiences across service branch, age, and similar subgroup characteristics (Cohen, Manion, & Morrison, 2007; Patton, 1990).

On the Internet, participants were solicited by a variety of means such as e-mails and postings on Web sites. The bulk of the Web-based recruiting took place via popular social media sites such as Facebook and LinkedIn. Both individual participants and relevant groups (such as those focused on Explosive Ordnance Disposal operators or technicians) were targeted. Appendix A includes sample recruitment materials.

Recruitment venues also included e-mails to members of specific ordnance companies in the United States military. In addition, hardcopy flier recruiting took place in Veteran Administration hospitals and in public spaces near military bases, such as coffeehouse bulletin boards.

Ease of access to a participant for an in-person meeting allowed the researcher the advantage of face-to-face communication, which enhances the opportunity to observe nuances in presentation. However, the nature of the group being studied had certain barriers that prevented in-person meetings for every case. Because the target populations for this study were (a) limited to a relatively small potential group of qualified candidates in a highly specialized field and (b) dispersed internationally due to the nature of their job, it was determined proximity was not an issue for participation criteria.

DATA COLLECTION MATERIALS

Data for this study were generated from two sources: questionnaires and semi-structured interviews. Therefore, a detailed analysis of the context for information provided from participants was essential in order to prepare data collection materials that would bear fruitful results. This context research also provided a background narrative helpful in understanding EOD user expectations about robots, their experience with robots prior to EOD work, and their strategies and practices of using robots every day in the military during analysis.

In order to become acquainted with the basics of participant experience, the researcher communicated via informal telephone calls and emails with three primary Subject Matter Experts (SME) within the U.S. military, two of whom worked within the EOD field and all of whom held active leadership positions. Books, government and news reports, and other formal matter relevant to the topic were organized to develop a narrative of the nature of EOD work in terms of job description, tasks, doctrine, training, and formal experiences surrounding the field.

In addition, material from organized EOD-related social groups—such as those on Facebook and LinkedIn—were reviewed to examine communication, community, and peer relations among EOD personnel in a less formal context. Together, reviewing these data groups established a tone and highlighted factors that could influence effective use of robots. This information was used to assist in the formation and refinement of the data collection tools described in this chapter.

A questionnaire is a commonly used device that if properly constructed (with understandable, appropriate, and relevant questions) and applied (with little distraction or observer influence), can be completed by a participant with little room for error in data entry (Fowler, 1988). The questionnaire was designed to "gather data at a particular point in time with the intention of describing the nature of existing conditions," (p 205, Cohen, Manion & Morrison, 2007). The questionnaire contained both closed-ended questions with limited response options and open-ended questions that encouraged the participants to write in their own response. The advantages of open-ended questions include the possibility of gathering unanticipated data from respondents and gathering information from people in their own words (Fowler, 1988), which is in line with the guiding principles of discovery in this study.

Interviews offer a rich way to collect information such as participants' attitudes and experiences after observing human-robot interaction. Patton (1990) states that we interview in order to discover things we cannot directly observe. Open-ended responses and a flexible approach to questioning enable the researcher to understand and capture people's points of view without predetermining the salient points of the interview with a scripted set of questions. The dynamic and interactive aspects of a semi-structured interview allow for follow-up and clarification on interesting, relevant or significant points. In semi-structured interviews, there are topics identified by the researcher to explore, but not all questions are designed and phrased ahead of time, thereby offering flexibility.

Questionnaire

The questionnaire was designed within the framework of the research's basic premise to learn about individuals and their experiences within the structure of EOD work and contained 12 questions, four of which offered multiple choice and eight were structured as open-ended questions (see Appendix B). All questions allowed users to write-in answers (paper version of the questionnaire), or speak at length (for Skype version of the questionnaire). The data from the questionnaire, combined with the information gained from the interviews, provided enough rich material to describe and analyze knowledge about the participants' specific to the context of EOD work, and their interactions with, and expectations of, robots prior to EOD, and then from EOD training through their careers. The questionnaires were designed to be analyzed in tandem with their associated participants' interview data and to provide potential insights as parts of the story.

For research purposes, the questions were broken down as follows:

1. Six questions about the participants' military experience, including age of first enlistment, length of time in service, and details of military branch and any elite unit or special forces membership. These questions were designed to gather basic data in a standardized way, and to initiate a rapport between the researcher and participant.
2. Three demographic questions about participants' age, gender and formal education levels, designed to record personal characteristics.
3. Three questions asking about any formal or informal experience with robots prior to their military service, designed to record knowledge about robots that may have informed expectations and opinions.
4. One question asked participants to describe a robot in their own words and was included with the purposes of (a) using the response as a springboard for follow-up questions during the interview and (b) providing more data for

analysis to discover patterns in ways of thinking about robots. This question was also repeated at the end of the interview to triangulate self-reported responses.

For qualitative researchers to understand the experiences of the participants, they need to cultivate trust so that the participant feels safe enough to share their story (Charmaz, 1991). In addition to gathering data, the questionnaire was the first substantive interaction between the researcher and participant beyond the administrative processes of recruitment and introducing the research, providing the initial opportunity to establish rapport. It is critical that qualitative researchers initiate rapport-building in order to build a research relationship that will allow the investigator to access that person's story and to facilitate participant disclosure (Goodwin, et al., 2003).

Since the stories of the participants in this study have particularly sensitive contexts associated with military settings, it is possible some of the stories disclosed were not told before due to the secretive nature of a mission, personal trauma associated with some aspects of the experience, or in an effort to withhold stories to protect friends and family from the danger associated with EOD work. Therefore, probing for information related to these experiences was not always an easy process. The questionnaire introduced the participant to the research process in a way that could potentially be less emotionally triggering than the interview that followed, using what King & Horrocks call "relatively unthreatening and simple questions" (2010, p. 55) to begin the study and set the tone for the interaction between researcher and participant.

Questionnaire results were transcribed by the researcher into Excel spreadsheets. Prior to the study, a mock-up of the questionnaire was pretested on a small representative group of a similar population. Feedback from pretesting was used to refine the questions and verbal instruction.

Semi-structured Interview

The semi-structured interview consisted of 12 questions (Appendix C) with follow-up questions possible. McCracken (1988) suggested that the interview format employ prompts or probes that give structure to the interview and allow the participant to use her own voice to relate experiences in an individual fashion. The interview structure applied in this research permitted spontaneous comments; however, where the participant did not spontaneously describe issues of interest in-depth, the researcher used conversational probes, which directed the participant toward additional narrative about the issue. This structure allowed the interview participants to speak in a detailed way about their experiences, ask questions, rephrase for understanding, and digress to related topics.

The interviews were conducted either in-person or via Internet voice calls (Skype) when face-to-face meetings were not possible due to a participant's geographic location. All in-person interviews were done in the informal setting of a coffee shop, while all participants who used Skype did so from a private work environment, such as an office, or a private space within their home.

All interviews were audio-recorded, allowing the researcher to take notes and guide the participant into areas in more depth or to related areas that appeared a priority to the participant. Immediately after each interview, the researcher reviewed the tape and field notes taken during the interview to consider what main themes emerged and what, if anything, needed to be altered to better word questions for the next interview. Based on the interview recordings and field notes, the researcher wrote memos in order to focus on learning and on adjustments in data gathering.

PROCEDURE

Nine interviews were conducted in-person, and 14 interviews took place over Skype. In each meeting with an individual participant, the procedure was identical. The participant read and signed the Informed Consent form for in-person interviews. Skype interviewees listened to an approved Oral Consent script (Appendix A) and agreed to participate or decline at that time. All participants followed through with the entire research commitment as described in the consent information.

Next, the participant completed the questionnaire (Appendix B). Skype interviewees were asked the same questions orally, and offered the same multiple- and open-choice responses as the paper version of the survey.

After the questionnaire, the researcher conducted a semi-structured interview with each participant. The researcher recorded responses and took field notes during the interviews.

Anonymity was maintained by assigning random numeric identifiers to participant data. In addition, potentially identifying information (e.g., colleague names, specific geographic locations, etc.) was obscured from the interview transcripts before they were submitted to the dissertation reading committee. Each participant session of the study lasted approximately 1 hour.

DATA COLLECTION AND ANALYSIS

Recruiting and data collection took place over a period of 7 months. The data was collected by the researcher in the form of hardcopy questionnaire results, one-on-one semi-structured interview audio recordings, and field notes. Each meeting with a participant lasted approximately 1 hour, with the interview portion lasting approximately 40 minutes.

Questionnaire data was transferred from paper documents (in the case of in-person meetings with participants) and audio records (in the case of Skype meetings) to Excel. All interviews were transcribed from audio recordings to Word documents by the researcher; a doctoral colleague at the University of Washington; and a professional transcription service. The aim of auditing transcripts was to ensure accuracy. The use of a transcription service to create the verbatim transcript required the researcher to audit all transcripts against the original audio-tape. The systematic checks through auditing was considered extremely important for building and maintaining familiarity with the data and, therefore, overall trustworthiness (Boyatzis, 1998).

As stated previously in this chapter, research included collection of data through questionnaire and semi-structured interview. The questionnaire and interview strategies included some purposeful restatement of the same or similar questions in order to triangulate participant responses. The use of more than one method to gather data allowed the researcher to overcome the weaknesses of each method of inquiry by the application of the strength of another.

Data was analyzed using qualitative thematic analysis (TA) techniques (Boyatzis, 1998; Braun & Clarke, 2006). Using this approach, the goal is to create descriptive, multidimensional categories, and to form a preliminary thematic framework for analysis by identifying something significant in the data as defined by the research questions and in some sort of patterned response within the data sets (Braun & Clarke, 2006). Boyatzis (1998) explained that thematic analysis is a process of "encoding qualitative information" (p. vii). Thus, the researcher develops codes (usually words or phrases) that act as labels for sections of data.

Words and phrases can be grouped into the same category by investigators as themes, based on their *prevalence*, which Braun & Clarke (2006) state is determined “in terms both of space within each data item and of prevalence across the entire data set” (p. 82). Prevalence may be determined in many ways and is a flexible characteristic of TA; what is crucial is consistency in applying the method of determining prevalence.

Two specific processes used to analyze transcribed interview data in this study were (1) memoing and (2) coding. Memoing is a “preliminary thematic identification” (Miles & Huberman, 1994, p. 56). Memos are a way of capturing and facilitating the analytic process, such as the researcher's personal reactions, notes regarding insights, connections, inconsistencies, and deviations from expected ideas. Moreover, the act of the transcript auditing acknowledged qualitative data analysis occurs with careful listening, (re-) reading, and memoing of the taped and transcribed text (Miles & Huberman, 1994). The second process used in initial data analysis was *coding*, a way of breaking data into pieces and rearranging it into categories to facilitate comparing it to other things in the same category and aid in the development of theoretical concepts. Miles and Huberman (1994, p. 56) define codes as "tags or labels for assigning units of meaning to the descriptive or inferential information compiled during the study." Qualitative research places primacy on the data, and the researcher works through the data inductively to determine categories, patterns and working hypotheses, often using words or descriptive phrases culled directly from the data to represent the patterns or categories. Patton (1990) states the purpose of coding the data is to "facilitate the search for patterns and themes" (p. 384).

In social research, *triangulation* involves the use of multiple methods and measures of the phenomena being studied in order to overcome problems of bias and validity (Scandura & Williams, 2000). *Investigator triangulation* is the process of using two people to examine the data as a way to reduce researcher bias by expanding the perceptual lens through two investigators or multiple observers (as opposed to a single observer), and then checking separate conclusions via memoing and discussion. Memoing and coding was done in multiple steps, concurrent with ongoing discussions via investigator triangulation between the researcher and a colleague. In this research, triangulation extends to triangulating analysts (Auerbach & Silverstein, 2003; Denzin 1989; Denzin, 2006; Patton 1990; Kokakaya, 2010) by using a second observer to analyze the data and compare findings. In this study, the author had a doctoral candidate colleague from the University of Washington as the second observer.

The coding was conducted by the researcher and her colleague in three formal steps: Level 1, or *open coding* phase; Level 2, or *focused coding*; and Level 3, *thematic coding*. In each case, the principal researcher and the second observer independently reviewed the audited transcripts. The goal of Level 1 coding was to examine the data and identify *key categories*: participant ideas, beliefs, perspectives, activities, strategies, concepts, incidents, terminology used or behaviors. Level 2 focused coding reexamined the Level 1 codes and further refined the categories of data. Level 3, or thematic coding, looked at Level 2 data findings to distill further into themes. Memoing was an ongoing process carried out by both researchers throughout transcript analysis. After clustering codes into groups, the primary researcher wrote thematic names onto note cards, one to a card. The cards were sorted into groups in ways that seemed natural, and clustered together pieces of related information, concepts, and ideas. This method was iterative, and categories and their properties were integrated into the process. By comparing and sorting data that is applicable to each category in this way, the method aided in reducing the data set further and developing new insights that emerged into thematic concepts. Finally, the primary researcher described theoretical concepts that emerged from these categories and themes.

The data of 23 participant-interviews is substantial. In order to springboard ways of thinking about the data, Level 1 used *a priori* categories based on the findings of similar previous research (Bartneck, Reichenbach, & Carpenter, 2008) about human-robot interactions in teams. Bazely (2009) states that using predefined categories for initial data coding is a valid starting point, and emphasizes that when doing so, this part of the process must be made transparent to explain that the anticipation of using the set codes will still allow flexibility for emerging categorization of the data. These initial categories were standardized with abbreviated names and definitions into a formal organizational system, or *codebook*.

At this level of coding, a codebook acts a framework for researchers to use as they read documents separately for analysis in order to provide structure for analytical procedure (Patton, 1990; DeCuir-Gunby, Marshall, & McCulloch, 2011). Coding data is a type of content analysis, and Patton (1990, p. 381) refers to this as the "process of identifying, coding, and categorizing the primary patterns in the data." Breaking down the data into coded units and developing a codebook is a part of content analysis. These categories were both *predefined* (based on what the researcher might expect to see via the a priori codes) and allowed to be *emergent* (developed as both researchers analyzed and developed new ways of looking at the data through memo and discussion). Because this research is exploratory as well as descriptive, the data analysis also promoted discovery through the inter-researcher discussion, multiple-step coding process, and memoing.

The act of note taking within the data analysis process is part of *memoing*, and ensures data points and important ideas do not get lost as researchers read through responses. Furthermore, Lincoln and Guba (1985, p. 342) suggest that memo writing about coding can help uncover properties of categories and help develop rules for assigning subsequent data to the category. Together, the codebook and memo framework also help identify areas to be examined more closely in the next coding levels by looking at outlier data that does not neatly fall into the predefined codebook categories. The Level 1 codebook used 38 codes as initial categories. All transcripts were formatted in a Word table that captured each interviewer question and the associated participant (P) response in associated cells, as seen in the excerpted example in Table 1.

Table 1. Transcript Formatting Excerpt

No.	Transcript	Code	Memo
1.	Researcher (R): Can you first tell me about your job in the military? I understand you are retired now, but tell me a little bit about what you did. Participant (P) 20: Initially, most of my work was done in the Equipment section, so I was responsible for doing little jobs. There really wasn't a lot…you'd have to charge up the batteries of the older ones, pretty much remove batteries all the time. And cleaning the shop, and all. Change batteries, swap out. And you know, check the source.		

This formatting choice was selected in order to create more easily parsed sections of data for analysis. Researchers independently read each transcript, and assigned codes to each participant response using the codebook as a framework. As the data was analyzed, researchers annotated cells next to participant responses with clarification of code choice, questions about appropriateness of code, suggestions for revision of code or its definition for the next codebook iteration, or general insights or thoughts about the passage, including emerging patterns or ideas.

When all 23 transcripts were open coded, the researcher and her colleague wrote summarizing memos to help establish a clear audit trail of the analytic process that included revealed data patterns and thoughts about reconfiguring codes. Furthermore, data analysis included memoed description of events, discussions, examples, relationships, exclusions, unanticipated classes of data, and alternative explanations.

In the data, patterns and themes emerged which were related to the activities, tasks, attitudes, and experiences of the participants and the context in which these elements existed. Some Level 2 data appeared in single category code patterns that were analyzed for their effect on the other patterns, while other segments of data were still labeled with multiple codes, or *co-occurring* codes. As with Level 1 open coding, the researcher and her colleague continued the memoing process, discussed separate interpretations of participant comments, and analyzed the conclusions of why segments had been assigned particular codes. Based on these preliminary findings emerging from the data, (which provided meaning for the categories), the codebook was refined with clarified code definitions and category development in order to proceed to Level 3 coding.

The goal of thematic coding in Level 3 is to organize the identified data categories into coherent themes or patterns by another close examination of the data. A theme captures something important about the data and represents some level of patterned response or meaning within the data set. Although themes sometimes characterize a prevalent response from participants, they more often demonstrate something important in relation to the overall emerging research questions.

In the last coding step, the researcher identified relationships between themes and synthesized the emerging findings into a cohesive summary. The process of the thematic analytical phase focused on identifying and describing implicit and explicit ideas within the data. Ways to identify areas of significance within the data included code co-occurrence, the development of graphic displays of relationships between codes and data sets through card sorts, and an iterative comparison and contrastive view of themes to rigorously ensure the validity of their structure. Theoretical models developed were constantly checked against the data. During this phase, there was also an examination of contradictions in the data and *outliers*, or data not categorized as significant thematically but perhaps interesting.

Finally, this study incorporated member checks as a technique to discover if EOD group member experiences resonated with the interpretation and report of the findings. Member checks presented an opportunity for participants or other involved subject matter experts to review facets of the interpretation of the data they provided (Doyle, 2007). Two group members —both active military EOD personnel—reviewed the study findings as electronic copies of Word documents, and were asked to clarify, explain, and question the themes and patterns that emerged from the data.

By providing an opportunity for these group members to assess the final analysis and offer alternative understandings, member check feedback was used to minimize distortion of qualitative data interpretation by the researcher. Overall, member check feedback was consistent with the findings described here. One member asked for a clarification of their meaning in a piece of transcribed interview included in the Findings, and this is noted accordingly. Their comments acted as a way to enhance the credibility of the final constructed interpretation.

RELIABILITY AND VALIDITY

As mentioned in previous chapters, no research has been done previously in this specific domain of EOD personnel and robot interactions through a social constructivist lens focused on the core human-centered issues of emotion, stress, attachment, and decision-making. The purpose of this study is to explore and describe the process, activities, context, and situations of EOD user-robot interactions.

Patton (1990) states that reliability and validity are two factors that any qualitative researcher should be concerned about while designing a study, analyzing results, and judging the quality of the study. Techniques used to assure reliability in qualitative work include detailing the investigator position in the research process, triangulation in data gathering and analysis, creating an audit trail in detail as it emerges during the data collection period, member checks, and thick description. These reliability factors are included in the description in the first chapter of the researcher's assumptions, the detailed explanation of data collection and analysis described in this chapter, and by using member checks of findings. A thorough research of relevant literature is also incorporated in order to ground this study. Triangulation of methods and data analysis combined multiple data collection methods, including questionnaires and interviews, as well as the use of multiple researchers during analysis. The audit trail via the memoing process has also been explained as a way of checking transcript accuracy and immersing the researcher in the data. Additionally, this study used member checks as a way to verify the accuracy of the findings and data interpretation.

Validity in exploratory research differs from quantitative research findings in that it attempts to accurately observe, document, and analyze patterns or characteristics of the subject of the study, not measure them. Thus, the validity of exploratory work may ultimately be evaluated by whether or not it has gained accurate insights into the phenomena being studied.

The work in this dissertation purports to look at everyday interactions between EOD personnel and robots. This subject matter can be viewed by some involved as sensitive or even classified information, and is otherwise limited in possible ways of being examined due to the necessarily private nature of military-specific research. Therefore, because of the restricted available direct access to the phenomena, a limitation of this work is the researcher's lack of opportunity to observe all aspects of the experience *in situ.* Thus, the choice to use participant questionnaires and interviews reduced the issues of gaining access to the community being studied. Furthermore, this process encouraged the examination of individual perceptions about robots and EOD work. Although there is a possibility that the researcher's presence influenced participant responses in a form of bias effect (Charmaz, 2000; Kokakaya, 2010), using questionnaires and interviews together reduced this variable by asking participants about their own experiences in their own words and not gathering data by strict observation of EOD activities in a natural work setting. The possibility of researcher bias was considered in the careful planning of the research design and analysis. When examining the collected data, a colleague from the Human-Centered Design and Engineering department independently coded questionnaire data and memoed findings. This work was compared to the researcher's data analysis and therefore reduced the chance of selective perception or individual researcher bias during the investigation.

Lincoln and Guba (1985, p. 290) also caution that qualitative research requires the "biases, motivations, interests or perspectives of the inquirer" be identified and explicit throughout the study and its write-up of findings. To enhance the external validity of this work, this study provides rich, thick description so that transferability is possible by the interested reader. Geertz (1975) explains *thick description* as a way of writing that places language and events in context and explains human behavior through reference to aims and intentions. Ryle (1968) philosophized that thick description is a way of interpreting things, or data, and writing findings in a way that goes beyond a simple narrative (the "what happened") and attempts to understand and explain motivations, and how these changed over time, in response to the circumstances in which participants find themselves (the "why it happened"), and discovering the intentionality of behaviors. Therefore, it is the role of this part of the research method to describe and reveal the participants web of experiences and their associated behaviors as clearly as possible.

One danger in this type of analysis and write-up is the potential over-interpretation of data, or letting the biases of the researcher seep into the findings. In this study, these two problems were mitigated by (a) letting the data indicate the point of saturation, and (b) clear description of methods and analysis, as well as inter-researcher checks. It was the intent of the researcher to continue to observe and to collect data until saturation occurred as indicated by a preponderance of non-exclusionary data. Inter-rater checks via the iterative discussion and memoing process contributed to the clarity of the findings and reduced the possible biases of a single researcher's analysis.

In summary, several specific activities assisted in maintaining quality control throughout data collection and analysis:

1. Purposeful sampling.
2. Recording and transcription of interviews.
3. Inter-researcher reliability.

4. Triangulation of data gathering methods.

5. Documentation via memoing of methods and methodological decisions.

6. Member checks.

7. Grounding findings in data.

The role of the researcher is central to constructing the findings in qualitative research. In this study, the researcher attempted to accommodate a neutral stance with experience researching human-robot interaction studies. Using the aforementioned checks ensures this study's findings are reliable and factual.

ETHICAL CONSIDERATIONS

General safeguards to the participants during the interview included the use of an Informed Consent form (Appendix A), a discussion of the interview agenda and timeframe, and the use of audio records to ensure accuracy. As part of the informed consent, a standard ethics protocol was read to the participant by the researcher prior to the interview. In addition, potentially identifying clues about participant identity (such as mention of geographic location, a colleague's name, or details of well-known battle incidents) were redacted from transcripts submitted to the researcher's reading committee as well as this final document.

SUMMARY

This research is exploratory and focuses on discovery. In that vein, this study did not intend to test the generalizability or predictive power of a preliminary conceptual model. Instead, it collected data through a variety of techniques and then used inductive analysis to identify and characterize patterns of behavior, dimensions and interrelationships in the phenomenon.

FINDINGS: FACTORS OF EOD COLLABORATION

This chapter presents an analysis of the study data. Throughout this study, the researcher sought to identify data that responded to the two research questions:

1. What are the activities, processes, and contexts that influence or constrain everyday EOD human-robot interactions?
2. What human factors are shaping the (robotic) technology?

The goal of the researcher was to add knowledge to the subject of everyday human-robot interactions in military environments, specifically involving EOD personnel by providing a rich description of the activities, processes and contexts of these interactions from the users own words and experiences. A second goal was to discover any themes that had not been identified in previous research concerning military human-robot interactions.

This chapter begins with findings from the questionnaire. Then, the findings from the interview data analysis are presented, including definition and descriptions of the two overarching theoretical concepts that emerged from the data: the Human-Human Interaction Model (HHIM) and the Robot Accommodation Dilemma (RAD). All the participants are presented using pseudonyms in order to protect their identity.

QUESTIONNAIRE RESULTS

In order to provide a richer description of each participant's background, during data analysis the questionnaire findings were primarily used by the researcher in tandem with each corresponding interview transcript to acquire additional insights about individual experiences. It is also useful to look at the questionnaire findings apart from the interviews to understand basic characteristics of the group. Therefore, prior to presenting the results of the data analysis that resulted in the detection of categories and themes, it is helpful to identify baseline characteristics of the 23 individuals interviewed.

All 23 participants completed the questionnaire prior to the semi-structured interview. Results of each question are presented in this section. (The results are summarized in Table 2, Participant Demographic Information.)

Age and Gender

Of the 23 participants, 22 were male and one female. Their ages ranged from 22 to 49 with an average 34 years of age.

Formal Education

This question offered the following response choices for highest level completed in education: High School, Some College, College Graduate, Some Graduate School, Master's degree, Doctoral Degree, Professional Degree, Other (with open text option).

Three participants reported as High School graduates, 12 replied they had "some college," 3 college graduates, 2 with "some graduate school," and 2 participants had Master's degrees.

Military Branch

Respondents were encouraged to check all options that applied to their military career. Participant membership in the five branches of the United States Armed Forces were as follows: 15 Army, 2 Navy, 1 Marine Corps, 5 Air Force and zero in Coast Guard. Five participants also identified themselves as serving in the National Guard and one in the Air Force Reserves, and U.S. reserve military forces, in addition to a primary branch.

Number of Years Served

The number of years served in the military ranged from 3 to 28 years, with an average of 13 years. Two participants volunteered the information that they are retired from service; one participant reported he was scheduled to retire within the year.

Age of Re-enlistment

This question was designed to provide additional background information that could be relevant to the interview portion of the participant's response. The age at re-enlistment ranged from 18 to 36, with many participants citing multiple re-enlistment ages over the course of their career. None of the responses were atypical.

Current Rank or Rank at Discharge

Enlisted rate indicates where an enlisted personnel stands within the chain of command, and defines pay grade. Every service has an E-1 through E-9 where "E" refers to "enlisted" and the numbering system runs from the most junior enlisted member to the most senior enlisted member. Enlisted promotions are awarded based on a variety of criteria, including vacancies, formal education, test scores, years of experience, exceptional performance, and promotion board approval. Additional rank scales include Warrant Officer (W) or Officer (O), but neither of these latter two ranks was applicable to this group of participants.

All participants ranged from E-4 to E-9. The most common pay grade reported by nine participants was E-6; only one participant reported E-4 and two participants were E-9.

Table 2 illustrates the numerical breakdown of the group's gender, age, education level, military branch, and rank.

Table 2. Participant Demographic Information

	Sample/23 Total
Gender	
Female	1
Male	22
Age	22-49
Education	
High school	3
Some college	12
College graduate	3
Some graduate school	2
Master's degree	2
Doctoral degree	0
Professional/other degree	0
Military branch	
Army	15
Navy	2
Marine Corps	1
Air Force	5
Coast Guard	0
National Guard*	5*
Air Force Reserves*	1*
Pay grade (current or at discharge)	
E-4	1
E-5	7
E-6	9
E-7	2
E-8	2
E-9	2
*Participants identifying themselves as National Guard and Air Force Reserves indicated their service was concurrent with their primary military branch.	

The tabular data above includes all responses to the closed-ended survey questions. The U.S. Department of Defense does not make demographic statistics for EOD personnel readily obtainable to the public, so it is not known how typical this sample is compared to the entire population within the military. The following results are from questions that encouraged participants to engage in an open-ended response.

Special Forces or Elite Unit membership

In the context of this questionnaire, Special Forces (SF) or Elite Unit membership refers specifically to military units that fall under the United States Special Operations Command (USSOCOM). Popularly recognized SF units are the Army's United States Special Forces (Green Berets), 75th Ranger Regiment (Rangers), and the United States Navy SEALs; all conduct Special Operations (SO). However, the term "Special Operations Forces" (SOF) has some variations between military branches. For example, Navy EOD are required to pass Special Operations Forces training and as EOD, fully integrate with SOF. All SOF and SF members are highly-trained and required to maintain a level of competence at all Special Operations core tasks / missions. It is possible to be categorized as EOD and SF. EOD personnel frequently work closely with SF regardless of their personal categorization as SF. This question was asked to gain insight into any additional specialized training or situations unique to SF that the participant may have experienced.

Of 23 participants, one reported being "attached" to a SF group, 2 (all) Navy participants identified themselves as SF; 10 participants reported they were not SF, and 10 left the answer blank. It should be noted that other than the two Navy participants who were clear about their SF membership status, almost all of the remaining participants offered verbal explanations in addition to their written responses quantified here, explaining they worked closely with SF and deployed and/or were integrated with SF units.

Prior Exposure to Robots

In order to get a fuller picture of participants' knowledge and expectations of robots in general before their standardized EOD training and individual military experiences, the survey asked about their interactions, if any, with robots prior to military service.

The survey prompt was "If you have worked on or with robots before your military service, please describe the conditions (industrial robots, humanoid robots, work, school, etc.)." The response choices to this question were: (a) None, (b) SciFi (books, movies, etc.),

(c) Toys, Home kits/Hobby, (d) Publicly available robots (museums, etc.), (e) Professional research and development on robots, (f) Education (classes, research or other academic experience), and (g) Other (open text). Participants were encouraged to check all that apply on the paper version of the questionnaire or to indicate all applicable experience in the verbal interviews. To get a fuller understanding of participants' exposure to robots prior to EOD work, the response options encompassed cultural media exposure via science fiction and toys as well as interactions with real robots.

Ten participants claimed prior robot interactions, spanning the response options, but with most indicating exposure to robots prior to their military experience through toys and/or science fiction.

Context of Prior Robot Use

A second question related to prior experience with robots was to clarify any context in which participants had encountered or interacted with robots with an emphasis on the workplace. Respondents could reply with open text to, "If you have worked on or with robots before your military service, please describe the conditions (industrial robots, humanoid robots, work, school, etc.)." The 10 participants who had claimed encounters with robots prior to military work—including non-work environment interactions—elaborated on the context of their exposure to robots in this response.

Examples of the more detailed responses included:

1. Remote-control toy; e.g., programmable remote control (R/C) tank.
2. Engineer experience designing/building automated assembly line equipment.
3. Undergraduate college course on industrial robotics.
4. Tactical robots.
5. Bomb disposal robots (Talon, Packbot, Andros, Vanguard) with work experience.

6. Home kit robots

7. Roomba (a home-use vacuuming robot).

8. SciFi books, movies

The overlap in response choices for those 10 participants that responded positively to both prior experience questions are illustrated in Table 3.

Table 3: Responses to Questions About Pre-Military Experience with Robots

	Responses							
P	*SciFi*	*Toys*	*Public robots*	*Home kits/Hobby*	*Professional Research*	*Education*	*Other*	*Context*
1	X	X		X	X	X		Designing and building assembly line equipment; college course
2							X	Tactical robots
3	X	X	X	X				Industrial bomb disposal robots
4	X	X	X					Roomba
5		X						Books, movies, programmable tank (toy)
6	X	X						Robot toys as child
7		X						R/C toys
8				X				R/C toys
9		X						Toys
10	X	X						Toys

Table 3 combines the findings for type of exposure to robots with an explanation of context (from the 10 responsive participants) for the interactions to illustrate the overlap in multiple-choice responses and connecting it to some context of experience.

Definition of a Robot (Questionnaire and Interview)

Another way to gain insight about participants' opinions about robots in general was to ask them to define the word "robot." Specifically, the question was: "In your own words, what is a robot?" This question was asked in both the survey and at the end of the interview. The goal of repeating the question was to give the participants time to reflect further on their idea of what a robot is and, if applicable, refine or expand their first response toward the end of the interview process.

In the response to the survey question, without exception, participants used one or a combination of the words in their definition of a robot: *tool*, *device*, *machine* or *(electro) mechanical*. The interview responses to the same question bore similar patterns, with occasional extended elaboration (see Appendix D for verbatim responses from the questionnaires and interviews).

SEMI-STRUCTURED INTERVIEWS

Analysis of the interview data revealed distinct patterns of beliefs, values, and strategies connected to successful EOD human-human interactions. This set of human factors in EOD culture are referred to here as the *Human-Human Interaction Model (HHIM)* These same factors identified by participants as part of successful human-human collaboration were rarely reported as existent in their everyday human-robot collaborations. Rather, the model for human-robot interaction that emerged encompassed the conflicting emotions and expectations of interviewees about robots in a set of consistent themes that are referred to in this work collectively as parts of the theoretical concept called *Robot Accommodation Dilemma (RAD)*.

Participants were asked questions pertaining to their career choices as well as a variety of questions about their training and work experiences, especially with robots, and were probed about their expectations, opinions, emotions, and behaviors associated with everyday human-human and human-robot interactions.

The first section of this chapter concentrates on insights into the patterns of human-human interaction identified by participants as being part of a successful model for inter-group partnership: beliefs, values, and strategies. The final part of this chapter reveals patterns of information discovered in the data regarding EOD everyday human-robot interactions. Throughout, there are exemplar participant quotes to illustrate findings. The voices of the interviewees are the ultimate data. The quotes included here are representative and help to richly illustrate what and how the interviewees think and feel.

In order to maintain confidentiality, participants (and specific robots) have been assigned pseudonyms. Additional potentially identifying information, such as references to specific geographic locations, has been redacted. All other aspects of the transcription excerpts are intact.

THE TWO THEMES: HHIM AND RAD

The two conceptual themes that emerged from the data are the *Human-Human Interaction Model (HHIM)* and the *Robot Accommodation Dilemma (RAD)*. The first theme, HHIM, is the framework of beliefs, values and strategies that the participants engage in to communicate and connect with other members within the EOD group at an organizational and team level. The participants described initial struggles with their first period of specialized intense training at The Schoolhouse, and how they successfully navigated these challenges. During The Schoolhouse training, they connected as new members to the EOD group by virtue of the common training and centralized geographic location with other EOD trainees from all military branches. They then participated in ongoing learning activities and everyday actions of their job as part of a team that interacts with critical care toward achieving mission results. In order to adjust, adapt, and overcome personal problems, challenges and distractions, participants needed to make a concerted effort to internally mediate all those frustrations and fears in order to progress from being uncomfortable in a new environment of EOD work to comfortable learning and working together toward common group goals. In order to be successful in EOD work, participants identified crucial factors in human-human collaboration, which were further parsed into the three categories of *beliefs*, *values,* and *strategies* during the analysis process.

The theme of *Robot Accommodation Dilemma*, or RAD, stems from participants' description of their experiences with EOD robots, which ranged from appreciation for the robot as a critical EOD tool, to frustration about robot technical abilities, to descriptions of the robot as an extension of the operator's self. The meaning of the words *accommodation dilemma* refers to two main patterns revealed in the data regarding participant human-robot interactions:

1. Regarding robots as critical tools, and the importance of thoroughly recognizing robot capabilities and limitations.
2. Defining robots as mechanical, yet still developing ways of interacting with robots as a technology (e.g., as an extension of self, humanlike, animal-like, or uncategorized "other").

Although there were a variety of reported experiences and opinions about robots used everyday, these two categories of interview data formed consistent and significant enough patterns to be identified and explained here collectively as RAD.

The HHIM and RAD qualities are not static within the EOD microsystem of everyday work activity, and are undoubtedly affected by interactions with other social systems. For example, an individual's expectations of robot roles may be influenced by fictional film or literature representations of robots that have nothing directly to do with EOD work. Figure 9 illustrates how HHIM and RAD qualities potentially impact problem-solving.

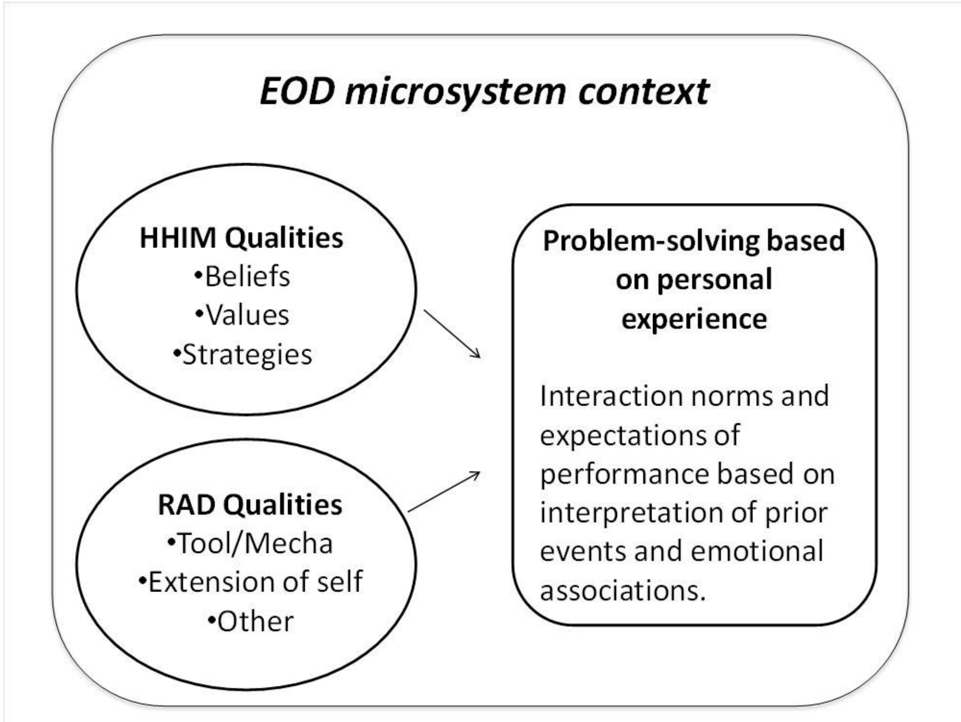

Figure 9. HHIM and RAD in EOD microsystem context

When HHIM and RAD qualities are examined within the context of the immediate EOD microsystem of everyday group interactions, it is possible to see the potential influence on their work and mission outcomes. Coconstructed reality influences decision-making, the approach to tasks, and how goals are accomplished. This process is guided by the influence of prior experience, interaction expectations, and robot technical limitations, such as those identified in HHIM and RAD.

Common Beliefs, Values, Strategies: HHIM Model

There were no specific questions about the best practices of human-human communication in EOD work, but participants raised the subject without explicit prompting. The concepts about successful human-human interaction emerged from the interview data in patterns defined in this work as *beliefs*, *values,* and *strategies*.

During analysis, *beliefs* were defined as a state in which an individual holds a proposition to be true, often with examples alluding to ways of thinking about their role as EOD.

The concept of v*alues* refers to a pattern of participant responses that reflect participants' sense of right and wrong or what *should* be, according to their experiences and the implicit and explicit demands of EOD work; values tend to influence attitudes, behavior and how individuals act.

Strategies referred to patterns of responses in the data that describe concrete actions participants use to do their work successfully. Some of these actions may be formally learned in training, while others are informally acquired through cultural negotiation on the job.

Throughout participant responses, these beliefs, values, and strategies emerged naturally into the idea of EOD self-identity as more than a sum of competencies, but beliefs about their individual and collective ability(ies) to exercise their competencies, especially under challenging circumstances. An important overarching concept about beliefs, values, and strategies is participants' confidence they can adapt their expert skills and core competencies effectively in the dynamic and challenging conditions of their job.

As seen in the interview descriptions of EOD training, personnel are given the situations to develop core competencies that come from modeled behavior, job experience, analytical reflection of situations, and performance practice under high physiological and emotional arousal. Although EOD missions have many different variables, the participants consistently expressed an overall strong sense that their learned skills, experience, and resources used to achieve RSP was portable between work circumstances.

"It's something that you're doing that very few people can do.": Believing the work is unique and challenging

The first questions of the interview focused on each participant's choices surrounding their entry into Explosive Ordnance Disposal as a career choice. (See Appendix C for the full set of standardized interview questions.) The variety of answers demonstrated a cross-section of individual reasons for choosing EOD work, ranging from monetary motivations for sign-up bonuses to responding to recruiter suggestions. However, two overarching patterns for underlying motivation for joining and enjoying EOD as a career were revealed: (1) ascribing uniqueness to EOD work, especially compared to other groups in the military and (2) the implicit and explicit challenges of EOD work. The ideas of *uniqueness* and *challenge* are worth discussing separately in order to differentiate between the closely tied concepts; these ideas are defined differently in this research in order to distinguish each as the participants implicitly do in the context of their responses.

Although a challenge might be considered something negative to a person reading the responses out of context, participants most often described the idea of a challenge in positive terms. Participants' choice to use the word "challenge" may come from common military cultural language, but, in participant responses, this word consistently described something associated with achieving positive outcomes from difficult situations. It was highlighted as especially important to their individual identity and as someone who identifies as a member of the EOD group.

The word "unique" was taken from the participants' own interview language because it was used repeatedly to describe interviewees' perception of EOD personnel and work, including their initial attraction to the field and their ongoing satisfaction with the career. The idea of uniqueness has to do with participants' self-identified desire for possessing a unique career, either in general, or within the military, and the belief that EOD work fulfills their definition of unique. A common pattern emerged in the data of participants describing this desire for a unique career, closely followed up with a statement about their belief EOD work and culture was a good career fit because it matched their existing unique or unusual personality, intelligence or social characteristics.

Furthermore, this belief of EOD of *uniqueness* was frequently something that rests on a mythos surrounding the image of EOD personnel as special, interesting, mavericks and individuals. Patterns emerged from the data that this mythos rested on two major points: (1) EOD work emphasizes *individual* (as well as group) evaluation of risks, and places an emphasis on effective intergroup communication, and (2) participant interactions with EOD personnel that helped form this image and influenced their opinion of the job before they joined. This former concept of retaining or expressing *individuality* in a military organization was a significant feature of uniqueness when participants explained their initial attraction to EOD work, and after becoming a part of the culture. The feeling of EOD as a unique group is reflected in this quote:

> *EOD used to be a lot like Special Forces, you know, this small group of guys that nobody knows what they do, and they sit in the corner of the base. You know, they pretty much do their own thing. Everybody leaves them alone. (Axel, 26, SGT, Army).*

The idea of EOD as separate, but still associated with the military, nods to the dual nature of this type of uniqueness as a desirable thing. The idea of individuality within the military is also illustrated in this response:

> *It's not the usual day-in/day-out rigors of the military. Whereas, an infantryman will do the same job, everyday, by the book…practice the same movement, by the book, everyday…one of the aspects of our job is to be unique and individual while staying within a certain set of guidelines. We're able to approach everything differently, use our imagination to defeat a problem. Working in small teams, it's definitely a distinct challenge. It's fun. (Irving, 31, SSG, Army)*

Irving's quote is typical of participants literally using the words *unique* and *challenging* in the same coded segment, as well as figuratively tying the concepts of uniqueness and challenge together.

During his interview, Roy described the "air" of EOD work by alluding to the latter part of the EOD mythos when he referenced the Oscar-winning movie *The Hurt Locker* (2008). He explained the film is a fiction-based cultural touchstone and a model for how non-EOD people may regard those in the field, whether that portrayal is considered realistic by actual EOD personnel, or not.

> *I chose EOD for the money, actually. When I was 16 I really didn't, I'd taken the entrance test to the Air Force and I qualified for all of the jobs. I really did- I certainly wanted to have a special- I wanted to do something unique…But one of the things about the EOD career field was there was a high wash-out rate which intrigued me…And I- my dad is a reservist in the Air Force as well, and when I had gone off for one of his reserve weekends, they had a family picnic up there, and I remember seeing those EOD guys, and seeing just their- I've never really had a really relaxed attitude compared to the rest of Air Force personnel that were there. They laughed a lot and they joked around and when you talked with them you could- I mean, they could put the humor aside and you could, you could tell that you were talking with someone, you were engaging someone who could engage back with you on a pretty high intellectual level. And so that was really rewarding for me.*
>
> *That- and in addition to going through our preliminary course and going through our school we started out with 30 from our initial preliminary course. And of that 30, only three of us graduated. And so the longer that I went into the career field, the more arrogant I became- you know, the taller I walked around. And there was an air about it.*
>
> *When people heard that, you know, this is what you did, amongst the Air Force- so before the movie 'The Hurt Locker' came out a lot of people didn't understand what we did. They didn't- they'd never heard the term 'EOD.' …They didn't really know what we did, and so as far as walking around on base we got away with a lot of stuff just because no one really knew what we were supposed to be doing. So that helped feed into that, 'Hey, we're EOD and we're the smartest guys on base.' (Roy, 27, SSG, Air Force)*

Roy describes a physicality here not just in terms of fitness, but in a way that defines members on sight to other EOD by a unique overall demeanor and being different from others. Hector told his story of discovering EOD work this way:

> *I was in the lead vehicle, so I was the one findin' all the IEDs, and dealin' with 'em and then workin' with the EOD, and gettin' em there and recording. And I was really impressed with 'em, 'cuz I didn't even know what EOD was before then. I . . . had been in for eight years at that point and I didn't know. So I was really impressed with 'em. They're sharp, and everybody was squared away. They're-, in the military, you always have guys that I call turds. They're just-, they're there 'cuz they couldn't work anywhere else, couldn't have a job anywhere else. They didn't have any of this. That was what really impressed*

me, and it's a brotherhood, too. They take care of each other. So they were the best and the brightest I'd ever met. So I wanted to go do that. (Hector, 27, SGT, Army/National Guard)

Hector's reference to EOD personnel as "sharp" and "squared away" further emphasizes his impression of them as being observably and impressively different from other troops.

During the interview process, when probing more deeply into these ideas, the unique nature of the job was also identified by participants as one that was preventative in its goals and results rather than destructive. There are other MOS within the military with similar goals of prevention as opposed to destruction, yet EOD work combines all of the elements participants identified as desirable, such as the ongoing rigorous physical, mental, and emotional requirements and challenges, as well as a culture that requires individual input in order to continually improve the training and skills.

Another example of this aspect of career uniqueness is reflected in this interview exchange:

> *Brady: I guess the reason I went into being an EOD tech was because it's one of the few places in the military where we get to help people instead of shoot people…It's my job to make the bombs go away, instead of dropping bombs, you know? So that was my motivation, pretty much. I'd talk to people who had been techs, and they told me it was a little more relaxed than the typical Army life…a little more closer, family kind of feel to the organization than just a 'Do this, do that, yes Sergeant, no Sergeant.'*
>
> *Researcher: That's interesting you said it seems a " little more relaxed." Can you tell me more about that?*
>
> *Brady: Well, I think it's because it's such a high-stress environment…when you're actually out there doing the job and interacting. When you're not on the clock, the other things seem tedious even though they may seem high stress to other people. Comparatively, it's no big deal to us. So if, I don't know, for instance, a normal infantry guy tells his Joe to go do something to do, he has to do it. You know, the Sergeant starts making him do pushups, the guy's gonna be stressed out about it. Whereas, it's just pushups. So what, who cares? You know? (Brady, 28, SGT, Army)*

As Brady's quote also illustrates, it is important to point out that participants described the uniqueness not merely from an ego-centered concept of betterness, but also as the perception they make a tangible and positive difference to others through their work.

Simon's explanation is typical of many participants' overall positive feelings about EOD work:

> *It's something that you-, that you're doing that very few people can do, and you know at the end of the day when you walk out of the office and you shut the lights off, and you lock the door, you made a difference. (Simon, 49, MGySgt, USMC)*

Simon aptly sums up the everyday motivations to be part of EOD that centered on more than individual aptitudes, but the ability to apply their skills in a way that keeps military personnel and civilians safe or safer in hostile environments and situations.

"If they're wearing an EOD patch, they're your family.": Valuing close relationships with peers

Related to the idea of uniqueness, almost all of the participants referenced the feeling of a sense of brotherhood, fraternity or family among EOD personnel, regardless of military branch. Earlier, Hector's quote about his impression of the interrelationships of EOD personnel as a strong part of his continued attraction to the work: "That was what really impressed me, and it's a brotherhood, too. They take care of each other." A pattern emerged from the participants' stories about the significant value they placed on this type of close bond with other EOD, as Simon stated this way:

> *One these few things with the EOD, the EOD program does is we talk to each other. We have-, everywhere that you go, you have a place to stay. You have a family. If they're wearing an EOD patch, they're your family. Maybe kind of dysfunctional, but they're still family. (Simon, 49, MGySgt, USMC)*

Simon explained the bonds of group membership go beyond one-on-one relationships with the people he knows, but extends to anyone he identifies as part of the EOD "family.' He also emphasized the practice of "talk" and communication as a scaffold for the close-knit feeling between members. This in-group sense of belonging surfaced as a tangible thing valued by the interviewees.

The other side of the concept of the inclusive nature of the concept of a family is, of course, the idea of exclusivity of those who are not in the same group. Many participants described their first experiences in The Schoolhouse training as the place where they established themselves as part of a cohesive group. Those students who do not have the aptitude are excluded by the demands of the process, while those who remain are included in the elite circle of qualified EOD graduates. Hector described the importance of the training and the subsequent process of narrowing down the group membership, and how this experience differed from his Army training experience prior to The Schoolhouse:

> *The thing about as an engineer, it's-, it's a big Army course, and you know you're not gonna fail. Nobody fails it. Even guys that are pretty much not smart at all don't fail it. They get 'em through, they'll hold their hand, whatever you gotta do. And so I hated that. You know, if you pass the test it should be because you passed the test and did good. But EOD, it's not like that. If you fail, you're out. You're kicked out of the school. You drop, whatever. I really like that. You keep all those guys that just can't hang-, even if they're good guys, they could get one of your buddies killed. And so I didn't- I don't wanna work with people like that. (Hector, 27, SGT, Army/National Guard)*

As seen in the above example and throughout this work, EOD The Schoolhouse training and everyday EOD experiences are well-documented as rigorous and demanding, mentally and emotionally. Based on this knowledge, probe questions were developed to identify issues experienced by the participants associated with the rigors of The Schoolhouse training and day-to-day EOD work and interviewees were asked to describe how these conditions affected them from an emotional standpoint.

Marcus summed up his feelings about the initial formal education at The Schoolhouse this way:

> *It is academically the most challenging thing that I've ever been a part of….But, it was exceptionally rewarding and it has kinda given me a perspective and a outlook on things that few people in the military share, and I feel kind of a-, for lack of a better word, 'elite' and unique and yeah, we're a pretty big deal. Yeah. It was- it's fantastic to be a part of this fraternity. (Marcus, 32, TSgt, Air Force)*

A pattern arose of participants describing this initial winnowing process via The Schoolhouse training experience as affecting the process of social cohesion (Kirke, 2009; MacCoun & Hix, 2010) among new EOD. The U.S. military is composed of many formal groups that nest in a strict hiearchichal chain of command, such as this Army example: Army>Corps>Division>Brigade>Battalion>Company>Platoon>Squad.

Other formal groups, such as EOD, are subsets that are part of these larger hierarchies. Participants repeatedly identified the The Schoolhouse as an important part of their feeling that they were part of EOD culture at a group level. In The Schoolhouse, the social structure of EOD is built in part by common training, as new group members learn the formal technical processes and rules for behavior, such as Render Safe Procedures, which are uniform across branches.

In addition, The Schoolhouse is where EOD begin to learn some of the overarching conventions of behavior, such as ongoing verbal communication during missions. The attitude of uniqueness appears to emerge for EOD personnel during this first formal training period, and with that, the first feelings of individual troops evolve into a "we," or the sense of belonging to EOD at this level prior to being assigned to a smaller unit. This subset of personal identity is part of the social structure interwoven with the operational structure of the military.

The sense of family or in-group association as they became immersed in their new role within the military relied in part on establishing bonds with peers who were successfully navigating The Schoolhouse environment. The shared common learning and survival experiences affected participants in a way that was portrayed by participants as challenging and ultimately an overwhelmingly positive experience. Patterns of specific strategegies for working successfully in the EOD field emerged as In a comment typical of how many also expressed their lasting impressions of The Schoolhouse, Jed shared his memories:

> *It was…it's classroom for about eight hours a day. Well, not classroom. It's training for about eight hours a day. And then generally between one to three hours of study hall at nighttime. So it's a lot of information. It comes at you very fast, and there's a lot of tests and performance reviews. You go through that to make sure you're picking up all the stuff. So, yeah…what I remember about it is just…and it almost was actually a really, really good time 'cause you're with a good group of guys, day in, day out, everyday. So you get a*

pretty tight bond with your classmates, as well as just trying to swallow all the information they're pumping at you as fast as you can. (Jed, 41, SCPO, Navy)

"I've got to make that decision, and I've gotta make it now.": Strategies learned within the culture for survival

From the data, specific strategies emerged that interviewees used for managing stress and cognitive overload, such as the compartmentalization of emotion and purposeful knowledge exchange between team members, in order to make life-altering mission decisions. According to participants, these strategies were learned through a combination of formal training and their observation of EOD culture and practice.

Regardless of what year the participants had gone through The Schoolhouse training, participants described the experience as *stressful*. Perhaps more significant is that the stress was associated with positive feelings. As Jed noted, the training as "stressful," but "….you keep doing what you have to do and you deal with the stress afterwards." The word *stress* was frequently attached to positive contexts or outcomes, especially in terms of something that can be channeled toward a goal, or otherwise purposefully ignored in order to focus on the tasks.

Another participant, Quinn, explained how he believed stress successfully triggered his training reflexively in a dangerous situation, "At that time I view that as a good stress, because training takes over" (36, TSgt, Air Force).

Participants also identified close ties between job satisfaction and the need to be mentally and/or physically challenged by the job. Roy explained his desire for challenging work, and how without that level of career engagement, he felt unfulfilled for a period of time:

The first four years of being EOD…this is before we were heavily engaged in [location redacted]. My supervisor that I had was really awesome and I was really proud of what I was doing. They kept me constantly engaged, constantly challenged. When I went to my second relief station I went to a much smaller shop with a much different mission….we went on one response *in two years. One documented response in two years, Stateside, and a very small range appearance which was basically glorified trashman. And so I really struggled with a sense of job satisfaction because basically, I would come to work in the morning, and for the last ten months of my active duty career I didn't go on one single fall Stateside, and so I really struggled with that satisfaction. (Roy, 27, SSG, Air Force)*

The connection between *challenge* and *stress* was often explained by participants as something to be (purposefully or innately) balanced via identifying and pigeonholing these states of being as separate conditions in order to survive the unusual circumstances associated with EOD work. Marcus explained his experience observing emotional compartmentalizing among his peers, and his insight about the emotional separation he uses to manage stressful facets of his work:

We have a unique ability to overly compartmentalize. So the-, the job is certainly stressful, but we tend to-, I have noticed that I tend to feel the stress after something wiped out, rather than while it's going on. I'm kinda detached from the fact that, you know, it's, such as a life or death situation and rather just kinda focus on what we've got goin' on at hand. However, afterwards could be, you know, a little unnerving of thoughts. (Marcus, 32, TSGT, Air Force)

Compartmentalization of emotion was one of several strategies the interviewees identified as part of their negotiation of everyday work. Examples of compartmentalization in order to work through challenges were discussed particularly often in relation to boots-on-the-ground work after The Schoolhouse graduation. Participants sometimes explained they felt it probable that some of this emotional compartmentalization was learned behavior from military training developed and applied with that outcome in mind, in order for people to effectively work though missions. However, these participants were also very aware of their ability to separate emotions (e.g., fear) from work while in the moment, and reflected on this tendency, sometimes attributing it to their own personality in addition to something learned via training or experience.

In this quote, Simon reflects on his ability to separate at-hand tasks and decision-making from dwelling on the possible long-term negative outcome of his actions:

> *It was my job. It's really weird.You don't think about the outcomes.Your concern is what's in front of you. I never thought about any of that stuff until afterwards. 'Cause it doesn't really do you any good. 'Cause just thinking about it, you can make a mistake and usually, in my line of work, you don't get to make a mistake. (Simon, 49, MGySgt, USMC)*

Rashad explains the need to separate immediate personal safety concerns from the more global mission-dependent tasks, and how and why he purposefully separates emotion from work if he is able to, in order to survive.

> *I was not very affected until the death of a friend, but . . . for the first 12 months of our deployment, I was a little bit concerned in my lack of emotion about . . . They-, our job is gory. We get into . . . I get around dead people and things like that. Aside from a U.S. casualty or something, which is emotionally difficult, a dead terrorist or something like that does not negatively affect me. The stress-wise, as far as . . . worrying that a IED is gonna blow up or something else, really wasn't there so much. I just kinda took the practical view of: "Worrying about it is not gonna help anything. I just need to be on my game. I need to be able to relax."*
>
> *I think that there's kind of a . . . I wouldn't call it a rush so much of what you think about, but the ability to go from inactive -- not doing anything -- to emergency situation quickly, was something that I had to do on a frequent basis. You would drive for hours and hours everyday and nothing would happen, and then all of a sudden, boom! Everything's happening really quick and it's sort of a . . . switch flicks in your mind and it's . . . it's work time, and every single ounce of your brain is focused on doing what you need to do, and everything else just goes out the window almost. As long as you have something to do.*
>
> *Now, at other times I've been sitting in the backseat of a vehicle while we're being ambushed and I have nothing to do but see if they got our ammunition. And then your brain starts to wander because you don't have anything to do other than hope that an RPG doesn't hit your window. But when I'm doing my job, I'm very focused on my job and making sure that everything else goes on and I'm thinkin' a mile a minute about 2,000 different things. (Rashad, 26, SSGT, Army)*

It is important to emphasize that this type of intentional and unintentional moving emotions into a box—to be examined (or not) at a later time—is a different process than the act of being immersed in an intense intellectual focus on the tasks at hand, as Rashad clarifies in the above quote. In fact, participants generally discussed their need to focus to an almost hyper-aware state on critical tasks involved for RSP of unexploded ordnance, rather than spending little attentional effort toward their job in an auto-immersion mode.

Closely tied to the ability to emotionally compartmentalize was the participants' recognition of their private thoughtful analytical process, an action often compared to an ongoing internal narrative, as in this example, also from Simon:

> *Well, you think of what can happen. Certainly, nobody wants to die. I wasn't afraid of getting hurt but you . . . you wonder about, you see people that are missing an arm, you know, digits, fingers, hands, you know, arms, whatever. And you know, you wonder, you know, what life would be like that. Or, you know . . . you know, if . . . the worse case, you're never gonna know, 'cuz you'll be dead. But just those little things. You know, the things that you're concerned with when you're going down there is keeping your eye on what-, what's there. Running scenarios through your mind: What do I do if this happens? What do I do if that happens? You know, what do I do with, you know…I come down here and this is something really opposite of what we thought it was? Can I, with what I have with me right now, can I make those changes in that scenario? And I've got to make that decision, and I've gotta make it now. (Simon, 49, MGySgt, USMC)*

Throughout the interviews, participants explained their conviction about the importance of decision-making and communication skills in order to work in EOD. Specific strategies used to communicate effectively between EOD group members emerged from the interviews. Identified as one of the most critical of these communication strategies is what was referred to in the data analysis process as *purposeful knowledge exchange* (PKE). Elements of PKE include intergroup (1) problem identification, and (2) negotiation of choices. Participants acknowledged there are specific required purposeful knowledge exchange activities in their routines, such as the verbal description of RSP to teammates prior to attempting the processes, or the writing of incident reports.

In this quote, Simon accounts for the ongoing learning process from intergroup negotiation of choices this way:

> *If I can get there by doin' this, and I can do it faster and I can do it more efficient, and I can make sure it's correct . . . Then the other three guys will either agree or will agree to disagree. OK. You do it that way, but I don't think it's gonna work so . . . Yeah, OK. Noted. Then when I go in, it works, OK. Yeah. Put that in the memory bank. That'll work. If it doesn't work, do not say, 'I told you.' OK. 'Here's where I think we went wrong.' And there are no real right answers. And we always used to tell people, 'If you don't have a thick skin, you need to find-, you need to go buy one.' (Simon, 49, MGySgt, USMC)*

Certainly, intergroup communication is part of EOD training. The willingness to listen and learn from peers and apply new knowledge was repeatedly expressed by interviewees as desirable as well as a necessary, ongoing and collaborative action between individuals and the team.

> *And so, and generally, what everybody has is a major and a minor. And you know, you have, so you get used to the one part. You have ground, you know, like hand grenades and landmines and the you have the stuff they shoot out the big guns. Then you have the air ordnance, and we have underwater ordnance. Then you have biological, chemical and nuclear. And then you have improvised biological, chemical and nuclear. And so you try to major and minor. And so I might be really good at one thing. Then we go somewhere and we're like, 'Hey, Bob, what do you think?' You know? And I'll defer to that person, and just not really get in on it. So, it-, it really just depends on what you feel you're-, and so nobody's really good at everything. There's a couple guys who are just really good at everything. But, you know, you-, you try to pick one and you-, and it's what you feel comfortable with. Does that make sense? (Leon, 45, PO1, Navy)*

However, purposeful knowledge exchange is not just a strategy used in the course of missions or as part of the formal processes of mission debriefing. Here, Jed articulated how discussing incidents with others in the group relieved stress, in addition to contributing to group knowledge through the analytical walkthrough of work-related tasks.

> *<u>Researcher</u>: When you say "blow off steam"…can you give me an example of that?*
>
> *<u>Jed</u>: We would…yeah…we would do all of that. Kind of the…it wasn't a really regimented thing, it wasn't planned or anything like that but kind of a habit we fell into…was when a team came back we'd all get together, we'd talk about what they had, what they did. We kind of put it up for discussion, of like, 'Is there anything else you could have done , is there anything you could see?' The guys that hadn't been out would ask questions and kind of say, 'Could you have done this, could you have done that?' So we'd break the situation down, make sure that the team had done everything they could right, as far as they knew.*
>
> *We'd try and come together on agreement on any improvements that could have been done, or things that could have been different, or maybe some risks that hadn't been seen at the time, and maybe in retrospect had seen, so we'd do that for just the training and improvement side of it and to keep everybody involved in what was happening 'cuz as time goes on the tactics…the enemy tactics change so it's good to keep current on the things as you see it.*
>
> *And in that…during that process, as you kind of go through everything and that's when the, you know, the jokes and the stuff and the laughing kind of*

come around and then…so you can…you start to make light of the situation once you have a good understanding of it; everybody who went through it is safe, this…and the improvements we have and they can start, you know, kind of poking fun of each other and laughing and having a good time with it after that. And then it just helps to kind of lighten the mood and keep everybody optimistic going through, you know, hard times. (Jed, 41, SCPO, Navy)

Jed's description of an informal mission debriefing as a way to manage stress via knowledge and humor illustrates how critical the verbal communication is between EOD, tactically and emotionally.

Robot Accommodation Dilemma

When speaking of their robots, participants shared an overwhelming sense of robot as something "mechanical" and a "tool." At the same time, there was a trend to explain the robot as an extension of self. In other words, there was little evidence of EOD genuinely mapping human-human emotions, affection, or expectations onto their robots as they would be expected onto another human friend or colleague. However, equally meaningful patterns in the interview data revealed participants often described robots as an extension of self, or as a team mascot or zoomorphic entity, or referred to the robot using language or cultural conventions usually reserved for living entities, such as referring to the robot as "he" or "she."

Participants described using the robot as a teleoperated stand-in for the human user, therefore often leading to associations of EOD inserting themselves into the robot's existence as an avatar, a thing that was part of their physical self. To a lesser extent, some individuals described this sense of self as if they inserted the operators' personality into the robot, and claimed being able to recognize characteristics of other operators via their robot tactics and maneuvers. In addition, a significant pattern emerged from the data indicating the interviewees viewed robots as useful tools, but with problematic technical limitations.

On one hand, because of robot usefulness in some situations, there was a consensus among participants that robots should be used instead of a human team member whenever possible in order to keep team members safe. In the words of Rashad (26, SSGT, Army), "The reason why we're using robots is because they're expendable." The sense of self-extension into the robot combined with frustration with it's limitations as a tool combine into a seemingly conflicting set of emotions that compose the accommodation dilemma.

"It's not going as planned…": Understanding robot capabilities and limitations

Across conversations with EOD, some the robots' limitations were a source of constant concern. Over the course of her interview, Sarah explained a frustration for her as an operator:

> *There's a lot of situations where you're dealing with it when you have a task to get done with the robot and you're trying to get it done quickly and it's not going as planned. The robots can be so…finicky, I guess. One second they communicate, the camera's working great, you know, you feel like you have it. Then you lose comms [communication] for two, three seconds and you're turned all around again. You don't know…you're disoriented down there. So there's lots of situations like that stick out. You just learn to take a breath and try to see what's going on. Stop for a second, turn the cameras, get oriented again where your robot is on and the position that it's in and start over again. (Sarah, 27, SPC, Army)*

Anxiety about robot reliability was repeated throughout participant responses. Aaron (31, SST, Army) expressed his feeling about working with robots in this exchange:

> *<u>Aaron</u>: But, I had a lot of issues with them not working at times…so, the whole thing about emotional relations with robots? The most common one I'd say, if we felt anything towards the robot, it would be anger and frustration.*
>
> *<u>Researcher</u>: Ok. Tell me more about that.*
>
> *<u>Aaron</u>: Well, most of them, we just used a radio control system on them. And it would lose comms [communications] a lot. Occasionally they would just do random crazy things. There'd be times when you'd be driving downrange and all of a sudden, it just starts spinning in circles. Not really sure what's going on with that.*
>
> *<u>Researcher</u>: You're saying you have no idea why?*
>
> *<u>Aaron</u>: No. It just happens to robots occasionally.*

Aaron's frustration was directly related to what he perceived as the unpredictable behavior of the robot, or its unreliability, and this was how many interviewees described their hesitancy about robots as something to be consistently relied upon.

Other ways participants expressed their concern over robot limitations was closely tied to lack of trust or lack of confidence based on their personal experience with robots.

> *I didn't have much confidence in that robot because of the downtime. Every time we tried to use it, it would either be so difficult to use…you'd just get it ready to go it would-, either the batteries would die the thing would make some maneuver that would make it swerve out of control and knock everything over. Bang into the wall or something like that. [laughs] I never had a lot of confidence in it in a real defensive situation. (Mino, 49, TSGT, Air Force)*

Participants described many situations that spanned a range of geographic locations and a variety of mission conditions to illustrate their perception of the inconsistency of robot behaviors, and the associated unreliable performance of robots and their limited capabilities. In several cases, participants reported jury-rigging robots on-the-fly (e.g., using duct tape to secure a tool to the claw) in order to overcome specific technical limitations. However, interviewees overwhelmingly appreciated the robot as a useful EOD tool.

This tension between reliance on robots and recognizing their limitations was also explained frequently by participants during the interview process. Jeremy, an Army EOD Team Leader, shared how he finds robots a practical tool, but also described their technical limits in some environments.[1]

> *Researcher: What do you think about robots now?*
>
> *Jeremy: I like them a lot.*
>
> *Researcher: Why is that?*
>
> *Jeremy: Well, because my experience in [location redacted]…you know, being a Team Leader, if we didn't have a robot, that means I would have to go downrange wearing the Bomb Suit and risking my life. So a robot, it's great for being the eyes and ears remotely to look at stuff, manipulate items…you know, from a safe distance. So it's saved a lot of lives, for sure.*
>
> *Researcher: Is there anything you don't like about robots?*
>
> *Jeremy: Other than…you [can] always have problems with them.*
>
> *Researcher: Tell me more about that. Can you give me an example?*

---

[1] Jeremy participated in member checking, and after reviewing this transcribed comment asked that his response be modified from the original statement referring to his experience with robots from "…you always have problems with them," to less concrete wording, suggesting a change to "can" instead of "always."

<u>Jeremy</u>: Well, like sometimes they lose connection you know so you may have to go retrieve the robot. It may get stuck; um, again, you may have to go down there and retrieve it. Other issues we have are some of the tools we use, like shock tube to place a charge downrange, sometimes the shock tube gets tangled up in the robot and there's no way around it, you have to go down there and recover it. But they…I think they've advanced a lot. When the Iraq war first started, they were still using the [robot model redacted] …which, it's a good robot for certain purposes. I'd say more for stateside response. For insurgent vehicles at a fixed location. It's not mobile or transportable by any means, it's really slow. It doesn't really work for response missions in Iraq or Afghanistan, just 'cause it's so bulky, cumbersome and slow. They've evolved into robots like the [robot model redacted], the [robot model redacted]…which, to me, are very functional and do the bare minimum for what we need to do for the majority of incidents in Iraq or Afghanistan. So, I'm glad we actually purchased those like in the '04 timeframe. (Jeremy, 34, MSGT, Army/National Guard)

Similarly, other participants warned that overreliance on robots, like any technology, can cause its own set of problems, such as limiting a user's practice of alternative problem-solving methods when a robot is not available.

I feel it's-, I look at it: it's artificial intelligence. And you only get what you put into it. So if the operator behind the robot isn't any good, then your robot's no good. But if you-, it all comes back into training. The more you train with it, the better off you are with it. And you have to know what the robot's limitations are. If you don't, you're in trouble. It is a matter of . . . you know, again, my fallback is to training. And the limitations of how far you know you can go with it. (Simon, 49, MGySgt, USMC)

In this quote, Simon also connected the idea of robots reflecting the operator or team capabilities and limitations, too, since the current semi-autonomous robots rely on human input for guidance.

"A team that's been through a lot is always connected to their robots.": Robots as something more than mechanical

When recounting their ideas about how to improve EOD robots, there were variations on the idea of self-extension increasing in the technology with robot humanlike hands to grip and move objects in a humanlike way, and improved audio-visual communications to better act as the ears and eyes of the operator.

One participant, Jed, explained his idea for the perfect EOD robot as full avatar of himself. Although an outlier in terms of his detailed description of the degree of humanlikeness, his basic idea of increasing humanlikeness in robot form and functionality is not an anomaly among the other responses regarding ideal improvements in the current technology.

> *Researcher:* *OK. If you could make a perfect robot for the EOD tech purposes, what features would you use or not use? Tell me about the robot you would create.*
>
> *Jed: It'd be a full human avatar.*
>
> *Researcher: A full human avatar? OK, tell me about that.*
>
> *Jed: Well, it would be me with remote control. So that I had all my capabilities, all completely into it, completely capable for everything that I could do, maybe enhanced a little bit with some kind of bionics, or something like that. But…so that you could go completely virtual reality. Go down and do exactly what you needed to do without any kind of limitations of your own body.*
>
> *Researcher: Interesting. Would you still want to work in a team?*
>
> *Jed: Yeah, I think so 'cause a team is a lot stronger than the individual members, so if you could have two avatars down there, two, you know, two robots, which we used several times, you could always have two people get better situational awareness. They can work together, cooperative tasking, that kind of thing. (Jed, 41, SCPO, Navy)*

Jed puts forth an extreme example of extending himself and humanlikeness into robot development compared to his peers in this study, but it is not discrepant from others who expressed similar desires for a robot with more humanlike affordances and abilities. Jed, a Team Leader, had previously contributed as an EOD subject matter expert representative on a military equipment review committee and in this role had participated quite actively in pursuing new ground robotics developments.

Thus, his thinking about how to improve EOD robotics had been focused during his experiences working with the committee, and he was encouraged as part of that role to develop new ways of solving current problems with the technologies and human-robot interactions. His detailed explanation of the avatar ideas for improvement emerged from his time dedicated to considering these issues.

Although there was a clear pattern of participant insistence that robots are tools and machines, as seen in the questionnaire and interview findings, there were still a significant number of instances when participants described emotionally meaningful parts of their interactions with EOD robots. The idea of being emotionally attached to a robot was dismissed by several participants. Yet, a number of significant stories emerged surrounding the possibility of attachment to robots. Emotional attachment to the robot was spoken of in three distinct ways: (1) robot as an extension or representation of [operator] self, (2) robot as mascot or zoomorphic entity, or (3) robot as humanlike other being.

During the course of the interviews, participants' facile explanation that a robot is a tool was often simultaneously couched with a portrayal of the robot as an extended version of themselves or another operator. One participant, David (22, SGT, Army), demonstrated this idea succinctly when he was asked to define a robot: "Yeah, like I said before, it's just an extension of my hands. It's a tool we use and to keep people safe."

Some interviewees went on to ascribe operator behavior to the robot, as in this exchange from Simon's interview:

> *<u>Researcher</u>: Can you tell me in your own words what a robot is?*
>
> *<u>Simon</u>: It's a . . . oh, there are two definitions. One is it's a . . . oh, what would you say? It's a mechanical invention designed to make our lives easier and safer. The other one is . . . it's an extension of our own-, of our own personality….As they have to take on your-, your personality after you've used them for a while. We have a tendency to think that if you have certain low attitudes that your robot, that the robot you're work-, that you operate has those same things. You have a certain way you're gonna do things and that's the way that robot's gonna do it, the way you want it to do it. Well, we say it in a humorous way. You can tell the operator behind-, you can tell the attitudes of the operator behind the robots by how it works. (Simon, 49, MGySgt, USMC)*

Simon clarified his statement to say there is a humor component to this idea of operator personality transferred to robots, but also explained clearly how operator personalities are conveyed via the robots they use, via problem-solving choices and behaviors.

In the following example, Ben explained how his thoughts about EOD robots have evolved, and shared an anecdote about how a colleague used humor to express his feelings about a destroyed robot:

> <u>Researcher:</u> *OK, so tell me…Let's go back to your training then, the first time that you worked with robots in the Schoolhouse. Did you have any expectations or thoughts about robots beforehand?*
>
> <u>Ben</u>*: Not particularly, I guess. No, not really. Wasn't really something I dwelled on all that much.*
>
> <u>Researcher</u>*: OK, and what about now? How do you feel about robots now?*
>
> *Ben: I think they're a very important component of the job now. I mean, they almost become like a team member.*
>
> <u>Researcher</u>*: I hear you say that they're important and it's…they're almost "like a team member." Can you tell me more about that? Maybe you could give me an example of working with a robot that sticks out in your mind?*
>
> <u>Ben</u>*: Well, you know, if…if we had, like, personified the robot, or give it, a, you know, give it a character, or give it like a…I mean, we would name them. And…yeah, and if something happened to one of the robots, I mean, it wasn't obviously… it wasn't on the same…anywhere close to being on the same level as, like, you know, a buddy of yours getting wounded or seeing a member getting taken out or something like that. But there was still a certain loss, a sense of loss from something happening to one of your robots, and then there would be the inevitable kidding around about it like one of my friends went off… was in Iraq, he…an IED detonated on his robot while he was trying to do a particular operation with it and everything, and so then when they recovered the components and everything…the carcass, if you will…and brought it back to base, and the next day there was a sign out in front that said, you know, the guy's name and underneath of it was like, 'Why did you kill me? Why?' [laughs] (Ben, 30, SSGT, Air Force)*

In Ben's example, he uses words that alternately confirm anthropomorphizing robots, then downplay its significance and explain it as humor. He then uses words to refer to the robot in a zoomorphic, or more detached way (e.g., the robot's "carcass").

In order to delve deeper into the territory of the first research question regarding activities, processes, and contexts that influence or constrain human-robot interactions, participants who were asked about their decision-making process when a robot was in clear and immediate danger of being harmed or destroyed.

Brady explained his emotional connection to EOD robots, and the outcome of losing a robot he worked with in close proximity for a period of time:

Researcher: Do you have any feelings or opinions about robots at this point?

Brady: They're probably the most useful tool that will save the most lives out of any tool in the Army. The sheer number of IEDs that robots have pulled apart, it's unfathomable how many lives they've saved. A good…a team that's been through a lot is always connected to their robots.

Researcher: Can you tell me more about that?

Brady: We named ours Elly, our TALON. Yeah. And I talked to her, when I'm at the controls or trying to take something apart, caps out of explosives or whatever...I'd be coaxing her, "C'mon honey." [laughs] They're kind of part of the family, almost, you know? I mean, you get back from an incident, you pull a robot out of the truck, you're spraying her off, washing her off, they're all dirty or whatever. And you think about it, it's saving lives everyday. So, it's very important. We like our robots.

Researcher: Were you ever in a position where the robot was in danger and you felt if affected your decision-making?

Brady: Affected my decision-making in the respect that I didn't wanna …like I didn't want to send it and blow up the robot? Um, yes and no. We make our decisions based on…as a Tech, we make our decisions based on how dangerous it is and how we can least put human lives in danger. There have been occasions where we didn't know what pulling on something would do. And instead of having someone put on a Bomb Suit and go down there with something with pins on it and pulling it, send the robot down. Is that going to blow up the robot? Much better than a human being. I don't think I'd really get sad in the respect that I'd miss a specific robot, because we had extra robots. But, the thing about each robot was that each robot is not the same. It has its quirks, you know, controls are looser, tighter or whatever and you get to know your robot. In that respect, yes, there is times that like, you know, I've had this robot for like four months now, and if it gets blown up I'll have to learn a whole new robot. (Brady, 28, SGT, Army)

Brady did name his robot and even interacted with it in some humanlike and affectionate ways, verbally coaxing it and calling it a term of endearment. However, he states any emotional affect on his decision-making is mitigated when compared to the option of putting a human team member in harm's way. It is a choice for him between robot and human, rather than robot or robot loss. Brady also expressed the issues of operator setbacks learning the "quirks" of a new robot, and therefore his preference to keep a familiar robot when possible. This set of somewhat conflicting sentiments that sway between playful affection toward the robot and the awareness of its inorganic reality is a typical example of the RAD phenomenon found throughout the interviews.

In another example about robot loss, Jed characterized his “rush of feelings” about losing a robot during a mission:

> *<u>Researcher</u>: And how did you feel when the robot was blown up?*
>
> *<u>Jed</u>: All kinds of things. Well, first of all, you’re a little angry that, you know, somebody just blew up your robot. So you’re a little pissed off about that. Just for the fact that now you’re down with capability and you’re one step closer to having to get out of the truck yourself. And then, you know, it’s kind of like, you know, here’s a robot that’s given its life to save you, so it’s a little melancholy, but yeah, but again, this is just a machine, a tool, that’s been out there and gotten blown up, something you might have had to be exposed to, so you’re pretty…generally pretty happy just about the fact that, yeah, it was the robot and not us. So there’s a whole rush of feelings going around that, and you know, the initial anger, a little pissed-offness, and just, hey, somebody blew up a robot. The fact that you’ve just lost a tool you’ve relied on a lot of times, and the fact that that tool just saved your life.*
>
> *<u>Researcher</u>: Right.*
>
> *<u>Jed</u>: Poor little fella. (Jed, 41, SCPO, Navy)*

Jed uses anthropomorphic language here, e.g., “a robot that’s given its life,” and then quickly reverts to referencing robots as “tools,” before referring to it as a “poor little fella.” This example again illustrates the awkward accommodation managed when participants spoke about their interactions with robots. In the interviews, this sort of human language indicator was unique to referencing robots, and not used for other everyday EOD tools.

Robots were also described as companions, either zoomorphically or as an anthropomorphic other. Wade’s story explains his experiences with one robot named with a traditional dog name, Fido, and another robot the operator named after himself:

> *<u>Wade</u>: I think, I don’t know, I mean they all sort of took on a mascot… Most of us named them, you know…so… It was the one, ‘Fido,’ and then one did ‘Ed.’ Ed, Ed. Yeah…this guy’s name was Edison, so he named his ‘Ed,’ because of the fact you did rely on them so much, you know. They did a lot of things that up until 2003 or earlier, you know, that the bomb techs were actually still having to do on their own, so…We do rely on them quite a bit.*
>
> *<u>Researcher</u>: And you named yours Fido? Why was that?*
>
> *<u>Wade</u>: Just ‘cuz it was like a dog. I mean, you took care of that thing as well you did your team members. And you made sure it was cleaned up and made sure all the batteries were always charged. And if you were not using it, it was tucked safely away as best could be because you knew if something happened to the robot, well then, it was your turn…and nobody likes to think that.*

<u>Researcher</u>: Did you just name the robot Fido, or did you paint the name on the robot or label it somehow?

<u>Wade</u>: No, I didn't paint it on, but it was always Fido. I'd say 'Fido,' and every team member knew. Ed had his name written on the arm, so it said 'Ed.'

<u>Researcher</u>: Did you name any of the other robots you worked with?

<u>Wade</u>: No, I didn't. I don't think so. [laughs] Just the ones you get to work with. Like I said, I think for a lot of the guys they sort of take on a mascot-type, you know, personality. (Wade, 42, SSG, Army/National Guard)

Connor shared details of the story behind one of his team's robot-naming as a way to deal with loneliness via humor:

<u>Researcher</u>: Did you ever name any of the robots?

<u>Connor</u>: [laughs] Every single one.

<u>Researcher</u>: Can you tell me their names? Tell me more about that.

<u>Connor</u>: It was more just a way to be funny and keep our morale up. Towards the end of our tour we were spending more time outside the wire sleeping in our trucks than we were inside. We'd sleep inside our trucks outside the wire for a good five to six days out of the week and it was three men in the truck, you know, one laid across the front seats; the other lays across the turret. And we can't download sensitive items and leave them outside the truck. Everything has to be locked up, so our TALON was in the center aisle of our truck and our junior guy named it Danielle so he'd have a woman to cuddle with at night.

<u>Researcher</u>: OK, do you have any other examples like that?

<u>Connor:</u> Well, Danielle got blown up so obviously she needed to be replaced. I don't know…We'd name them after movie stars that we see at theater, or music artists, somebody popular, and then we'd always go to vote to decide on. (Connor, 22, SGT, Army)

From the interviews, a pattern emerged that naming the robots and assigning similar lifelike characteristics to robots was influenced by the amount of time spent with a particular robot. And, as in the following example from Jed, may also be influenced by the age of the operator, as well as the overall group dynamic:

<u>Researcher</u>: Why do you think you named some of them, and not others?

<u>Jed:</u> Team composition. Team in [location redacted] was a younger team, bigger team, and just couple of the more of the younger, prankier kind of guys would name 'em. Had an older, more mature team in [location redacted] and..so it wasn't…I don't know, it just kind of never came up.

<u>Researcher</u>: Did you personally, or did you notice anybody else ever treat the robot as anything other than a tool? For example, you said you named it.

<u>Jed</u>: Well…Yeah, it was always…you kind of personify a little bit with the robot, anthropomorphize it, I guess. So, you know, when you talk about the robot…and he or she, depending on which one it is. Yeah, and there's, there's actually does be…a little bit of affection to it, especially as time goes by and…it's done a lot of the work that could have killed or injured you, so there's a little affection drawn to it to… It's more than just a…you know, it's not a hammer, it's not a wrench, it's not completely inanimate. Just for the fact that, yeah, you see this out there, you see it moving around on its own or seemingly on its own doing stuff that you don't want to do. So yeah, you kind of start to lend a little humanity to it, I guess. Sort of….not a lot, but you definitely build an affection to…On the one side, it is an extremely capable tool that you can put a lot of reliance on, so you treat it as that. You take care of it, you maintain it, and you make sure it's capable of doing what you want it to do, and then while it's doing it, yeah, you can kind of…you put a little humanity into it and anthropomorphize it. And I guess it just kind of helps to identify, maybe, a little with it? Or you just realize of…how much work that's doing and, you know, you can be exposed to, so…yeah, I dunno.

<u>Researcher</u>: You mentioned "he or she" depending on which one it is. What would determine a "he" versus a "she" robot?

<u>Jed</u>: That's the operator.

<u>Researcher</u>: Are you saying that they would just randomly pick a gender? Or, for example, if it was a woman operator, they might tend to call the robot a she?

<u>Jed:</u> No, actually, I think…I hadn't really thought about it before, but I guess now that I think about it now, the married guys, the robots were always guys. And for the single guys, I…which I only had two…the robots were girls. And you know, I don't even…I don't even know if they were talking about like ex-girlfriends or just like girls in general.

<u>Researcher</u>: That's interesting.

<u>Jed</u>: They took care of them so I guess they weren't the ex-girlfriends. [laughs] (Jed, 41, SPCO, Navy)

Jed explained in his experience, the robots' gender was assigned by the operator, and like with Connor's previous example, it was an opportunity to acknowledge the human loneliness and lack of romantic companionship during deployment. Jed's explanation of the human-robot caretaking process illustrates a condition that points to some level of emotional investment with the robot, based on long-term care bestowed from human to robot. ("You take care of it, you maintain it, and you make sure it's capable of doing what you want it to do.")

SUMMARY

In conclusion, this group of participants reported that they possessed a consistent set of beliefs, values, and strategies about human-human interactions that they practiced with their everyday group members. Furthermore, they felt successful EOD work rested in this human-human interaction model they had developed via formal training and from the cultural norms of EOD as a group. The subcategory statements of *uniqueness*, *challenge,* and *family* are significant words culled from the self-descriptors of participants, indicating they have an affinity for these attributes or states.

Participants described a different set of experiences and feelings about their interactions with robots, and there appeared to be some sense of an evolving dynamic about how to treat or regard the robot consistently. The EOD personnel interviewed demonstrated an understanding and acceptance of robots as a tool or mechanical device, but also often assigned them human- or animal-like attributes. The tasks the robot performs, including being a stand-in for humans in dangerous situations, also helped inform the operators' opinions about how to categorize robots as an extension of self or tool. The danger the robot is in and chance it could be incapacitated or destroyed was reported to not affect operator decision-making. Additionally, participants understanding of a robot's technical limitations created associated feelings of user mistrust, or at least concern about its reliability.

The value of the questionnaires and interviews proved to be less about discovering whether EOD personnel became attached to robots, and more about discovering the consistent model of beliefs, values, and strategies (HHIM) participants applied to their human interactions, and their complex and conflicting experiences when interacting with robots (RAD). As EOD robots are developed with more human or animal-like affordances, tasks, or roles, these two evolving EOD communication models should be further monitored and evaluated for their impact on team communication and decision-making.

The last chapter will discuss the implications of the findings in detail and will provide suggestions for further research.

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

The title of this work was inspired by the U.S. Navy EOD Ethos, and in particular, the following line that describes an EOD group member as a "quiet professional" (see Appendix E for complete Ethos)[2]:

> *I am a quiet professional! I strive to excel in every art and artifice of war. I adapt to every situation and will overcome all obstacles. I will never fail those who depend on me.*

The term "quiet professional" is evocative of a person that is a dedicated specialist whose knowledge and skills are always evolving, and who operates within the boundaries of a professional credo. This Ethos is part of military culture and the term is used in the EOD world as self-description. Thus, the term seems particularly appropriate to attach to a study examining EOD personnel interactions with everyday robots through a social constructivist lens and in the context of their social systems.

The primary purpose of this study was to increase knowledge about a specific population, Explosive Ordnance Disposal personnel, and their everyday interactions with robots. The first part of this chapter discusses the findings in terms of the first research question guiding this study. The second part interprets the study's results within the framework of human factors shaping the (robotic) technology. Then, study limitations are discussed in terms of this work's boundaries and scope. Finally, the conclusion discusses the theoretical and practical implications of this study and suggests future research.

DISCUSSION

It became clear during the analyses of the data that consistency existed across experiences. The linkages among coded categories were revealed and reestablished

[2] Although this specific creed is associated with the Navy, the term "quiet professional" is also used within the military and in popular sources to refer to Army Special Forces (SF) groups (Lowers, 2013; Scarborough, 2012) or, more broadly, other highly trained troops.

through iterative coding processed through an interrrater system and substantiated the consistency of experience among the participants.

INFLUENCES AND CONSTRAINTS ON INTERACTIONS

Categories of commonly shared beliefs, values and actions were identified in almost every individual case, forming the basis of what was termed the Human-Human Interaction Model for this study. The HHIM framework was a way of understanding common expectations about human-human interactions within EOD work, as described by the participants. The ideas of *group uniqueness*, needing or seeking *mental and physical challenges*, high sense of *self-efficacy* and practices of *thoughtful analytical reflection* and *purposeful knowledge exchange* were identified as significantly meaningful trends among their experiences.

Consistent within categories, participant relationships to each other were described using expressions such as *brotherhood*, *family*, and *trust*. Whether these patterns are a result of group training and general military indoctrination, personality type(s) intrinsically attracted to the nature of EOD work or individual adaptation to the larger system of group expectations is unknown. Further research may find more common roots of these beliefs, actions, and values useful in order to better understand how organization-level policies and robot design can adapt in order to influence EOD attitudes about robots used everyday.

EOD group size varies between functions and service branch, and evolves according to organizational policy and changing strategies. Each group has similar training, but individuals offer a unique perspective. Therefore, the group constructs its own dynamic. Individuals may have different motivations for joining EOD or pursuing a military career, but generally described excitement about different aspects of the work and also working with similar-minded others who share common beliefs, values and actions. The intersubjectivity of the work is often rooted in the common interests between individuals (e.g., seeking uniqueness; interest in working with explosives), and developed with the social patterns created for them (such as formal military rank) and those they negotiate and extend via an understanding of meaning within each group.

The interview data analysis revealed distinct patterns of beliefs, values, and actions connected to successful EOD human-human interactions, but these same factors identified by participants to successful human-human collaboration were seldom present in their human-robot collaborations. In relation to robots, the common experiences that emerged as patterns significant in meaning and through their repetition centered on experiences and concepts such as *frustration*, *robot as self-extension*, *robot as other*, and *robot as tool*.

In addition, participants described a tension between their high regard for robots as an important work tool mixed with feelings of irritation over the robots' technical limitations, and were therefore hesitant to become too reliant on robots as an ultimate solution for every mission. These conflicting reports about participant experiences with robots, and their subsequent use of the robots, is the basis for the Robot Accommodation Dilemma (RAD).

The attribution of zoomorphic or anthropomorphic traits to the robot were explained by participants as rooted in small-group/team dynamics, age of the operator, length of time working with a particular robot, troop loneliness, boredom, humor, and also self-extending operator physical or emotional selves into the robot. In other words, a variety of human-centered factors affect how operators view the level of human- or animal-like traits they assign to the robots they work with every day. The robots' design, behavior, and tasks influence these emotions and decisions, but are not the only things that impact participants' associating lifelike characteristics to these service robots. Some personnel explained the robots' evolving social role within the group comparable to that of a pet, team mascot, extension of self, or a combination of these characters. Pseudo-team mate status was also sometimes constructed onto a robot's role, but this always became known in the context of explicitly assigning this part with a dose of humor.

As stated earlier in this work, the core proposition of social constructivist theory suggests social and symbolic processes produce patterns of shared concepts, understanding, and behaviors that spring from things beyond the basic acts of information processing in organizations. The findings reported here provide evidence of effects consistent with social constructivist premises, in support of existing theoretical assertions. In particular, the qualities of RAD resonate with T. Duffy & Cunningham's statement that a shared understanding of our reality is contructed "towards creating a world that makes sense to us" (1996, p.188).

At this time in EOD work, the robot is very much described and defined by personnel as a mechanical thing—a tool. However, during the course of prolonged human-robot interaction and proximity, the robot is sometimes assigned organic traits, such as gender, association with a living person (e.g., a stand-in for the operator; or a celebrity), or inclusion in social rituals (e.g., painting a name on the robot and including it in team photos). In other words, the participants are still constructing ways of working and living with this new technology in ways that "make sense" for their social systems.

All participants defined robots as a tool, mechanical system, or machine, yet many also easily assigned robots traits and characteristics of a pet or person. In other words, the people interviewed for this study were very aware that the robots are inorganic, and were simultaneously self-aware about any attribution of organicness to the robot was done so in a playful or very conscious manner, or generally with limited emotional investment on the part of the user. The operators clearly stated the robots did not merit or receive humanlike treatment, nor did they feel the robots evoked strong emotional responses purposefully (by design) or otherwise. Nass and Moon (2000, p. 20) explained similar human social interactions with computers, in which people modeled a mindful awareness of the computer as machine combined with an unawareness of treating the computers as humanlike social counterparts, as *ethopoeia*, or "….a direct response to an entity as human while knowing that the entity does not warrant human treatment or attribution."

In other words, people automatically and mindlessly apply social rules to their interactions with computers because humans are inherently social. This term, as Nass and Moon (2010) defined it in relation to human-computer interactions, has some application to this work. The study participants indicated interactions with robots that could be identified as those based on a human-human interaction model—such as naming or otherwise assigning the robot human or animal-like attributes—were purposeful, and done with an air of self-awareness and humor.

On some occasions, users referred to the robots in human ways, using personal pronouns and human terms to refer to the robots, even though this study's users unanimously categorized robots as mechanical tools. Parallels between how participants described robots as people may be in some cases be attributed to linguistic convenience as opposed to social considerations. Yet, a pattern emerged from the data that the robots were frequently viewed as something more than mechanical. Furthermore, participants' treatment of robots was not triggered by (intentionally designed) robot social cues, although it is possible the robots role, design, or other characteristic, unintentionally triggered a human social interaction.

However, while interviewees may have used humanlike social rules to interact with robots in some situations and circumstances, they did not use a humanlike model to assess the robots' capabilities. Additionally, some operators indicated a sense of their own self introduced into the robot's actions, intentions, or behaviors. Thus, for the purpose of this study's findings, the term RAD may be better suited to describe this expanded set of human-robot phenomena together. The conceptual framework of RAD describes how participants are challenged by the problems of conflicting emotions, expectations, and experiences when interacting with EOD robots, and how they struggle to fix the identified problems in order to succeed. These problems are based in discovering new rules for interacting with a tool that carries out some humanlike tasks, and, in some contexts, acts as an extension of self or the operator. Belk (1988) explained people naturally extend a sense of self into things that they control, craft, personalize, or alter (e.g., Wade shared how his team's robot operator named the robot after himself). "Objects in our possession literally can extend self, as when a tool or weapon allows us to do things of which we would otherwise be incapable," (Belk, p. 145). Groom, Takayama, Ochi, & Nass' (2009) research suggest people are more likely to extend themselves into robots with less anthropomorphic forms than humanlike ones, indicating a possible factor in participant responses to the current models of EOD field robots.

Although there was less information about whether the social interactions with robots strongly influenced decision-making or otherwise affected mission outcomes, it is a worthy topic to investigate in further research as team configurations change and robot design evolves. There is evidence described in the findings of connections between HHIM, RAD, and problem-solving as dynamic qualities within larger social systems (e.g., Simon explained how operator personalities can be expressed via how they choose to use their robots to carry out tasks). Therefore, this sort of first-hand information from participants indicates where to look further for points in the social systems that can be manipulated in order to change these qualities for different effects.

Human factors are the significant part of this dynamic system of interactions, and so are part of the equation that need to be considered in new ways for the new jobs working with the new machines. Formal work groups, such as EOD teams, are the sites of important social influences and reality construction processes. For that reason, continuing to investigate the human variables (e.g., group member age, personality, emotional effect, attachment style, team cohesiveness, and so on) of these exchanges is an important piece of understanding the overall dynamic of the human-robot interactions in any similar scenario, from the initial training stage to expert use.

This study's participants reported little initial hands-on formal training with robots in The Schoolhouse[3]. However, the EOD personnel tasked specifically as robot operators continued training—formally and informally—once on the job. All participants described active group member roles that required ongoing communication and developing a shared understanding of each critical step in a mission, as well as post-mission analysis, in order to produce an outcome created, in part, via a social learning process. Although final decisions are made by the Team Leader, each member's contribution in the form of communication and/or negotiation is often considered an important part of the task or mission outcome (positive or negative), and because of this expectation of team behavior, every person described a sense of ownership.

HUMAN FACTORS SHAPING THE ROBOTIC TECHNOLOGY

As demonstrated with the interview stories that described jury-rigging robots in order to increase or improve their functionality, there is an immediate physical aspect to the ongoing design and function negotiation between the users and the robots. Another example of the iterative design and function negotiation is direct user feedback to the robot developers. One example of direct feedback to robot design decision-makers was Jed's service on the military equipment review committee, where he had the opportunity to provide suggestions about the directions robot design might take. In both jury-rigging and design feedback examples, there is an obvious circle created as the robots (or objects) impact EOD, and then EOD create and influence (construct) new ways of working with and designing robots.

[3] The exact amount of hands-on robot training in the EOD school varied by the year the participant attended, as the formal training evolves with incoming information and new technology.

STUDY LIMITATIONS

It is beyond the scope of this dissertation to address varied political opinions about U.S. military actions, the complex ethical issues emerging in defense-oriented HRI, or the fiscal and production timeline challenges in iterative robot research and development. Instead, this contribution focuses on the human side of EOD individuals and teams—the areas most easily accessible for research, and the most directly influenced position by the introduction of humanlike robots into everyday work.

It is in unknown from this work whether the identified patterns of successful human-human interaction are a result of group indoctrination and training, personality type(s) intrinsically attracted to the nature of EOD work, or individual adaptation to the larger system of group norms and expectations. Further research may find the roots of the human-human interaction characteristics identified here as *beliefs*, *values,* and *strategies* are useful knowledge in order to scaffold better understanding of how robot characteristics and robotic training can adapt in order to influence EOD attitudes about robots used everyday.

Several limitations affected the outcome of this study, including the small sample size that did not allow further research into subgroup norms and differences between military branch EOD experiences. Two factors contributing to the small sample size included the time constraints of the study and the difficulties of recruiting qualified participants. Recruiting proved to be more time-consuming and involved than anticipated because of the nature of the participants' work. Several interested and qualified participants offered to take part in the study, but were deployed before they could take part, or were currently deployed or similarly unreliably available due to work conditions, and therefore unable to participate while the study was in progress.

The nature of qualitative research findings is that they sometimes cannot generalize the experiences of this group to a larger EOD population's experiences with robots. As a result, these findings indicate relationships, not empirical certainties.

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK

The researcher intends that this study lay the groundwork for investigations into related research. Therefore, a number of implications from this study are explained as a series of questions that may be explored in subsequent research. These questions reflect a synthesis of the data presented in the Findings chapter and the discussion of those findings presented in this chapter.

To summarize the findings:

1. There is an identifiable human-human model of interaction within the studied group with clear expectations, beliefs, values and strategies.
2. Operators categorize EOD robots as tools, but sometimes interact with them in ways that resemble human-human or human-animal social interactions.
3. A separate interaction model with its own parameters and expectations exists between user and robot, forming the RAD dynamic.
4. Unlike HHIM, RAD is a one-way social model since (EOD) robots are not capable of returning purposeful social signals or communication. Furthermore, robots' lack of reciprocity and inability of the robot to be a fully participatory social actor is perhaps a significant parameter of limiting them to the users' "tool" category at this time.
5. Robots are a technology that transforms personal experience and social relations by forcing users to find new ways of acting with this new sort of agent; the robot is a tool, but one that performs some human-like functions and actions.

Questions that arise from this study include:

1. What organizational factors are producing social role changes in EOD robot use and influence the social dynamics between EOD and robots used everyday? Examples of these factors include (a) standardized The

Schoolhouse (e.g., training) procedures, (b) evolving (robot) designs/behaviors/role, (c) changing (EOD) group size, (d) popular culture representations, or (e) a combination of these inputs?

2. What impact does everyday robot use have on team dynamics? What are the outcomes of these changes?

3. What are the different human-robot interaction patterns for EOD in each branch of the military?

4. How can researchers deeply explore other military subgroups that use robots every day, such as those working with Unmanned Arial Vehicles, Unmanned Combat Aerial Vehicles, Unmanned Ground Vehicles, and similar unmanned semiautonomous systems?

5. Why is a robot viewed as an extension of self? What frustrations with the robot’s capabilities are connected to the operator’s sense of frustration at self? What sense of self is lost or lessened with the unintentional loss of a robot, and does that influence user emotions and behaviors?

6. How can roboticists leverage any human tendencies of projecting a sense of self into robots into the robot design, behaviors, and tasks?

7. What robot physical appearance, behaviors, and tasks trigger human tendency to anthropomorphize or zoomorphize robots? When are these triggers desirable for military scenarios and when should they be minimized or eliminated?

8. What trust and team cohesiveness human factors will arise as robot physical appearance, behaviors, and tasks evolve? What do human-robot trust models look like, and does human-robot trust develop in a model similar to human-human trust?

9. What level of responsibility will operators feel as robots take on increasingly complex and autonomous tasks? How will these changes affect team members with a high sense of self-efficacy or achievement?

10. What (new or existing) Post Traumatic Stress Disorder issues surrounding human-robot interactions arise if users extend their selves into robots used every day, or otherwise imbue them with human- or animal-like socialness?

Based on the areas of future research suggested here, there is a need to develop rich psychological scales for measuring the mental states of robot users and analyzing related social trends over time. In particular, the body of existing literature (Bates, 2002; Carpenter, 2013; Hogan & Hogan, 1989; Kolb, 2012; Mori, 1970/2012; Murphy, 2004; Scholtz, Young, Drury, & Yanco, 2004; Singer, 2009) supports the need to explore the human factors related to human-robot interaction, and to attend to the issues related to operator stress and anxiety.

As stated previously, people often name the everyday tools they interact with—such as cars, computers, tanks, or rifles—after spouses, significant others, and Hollywood actors or other popular characters (Belk, 1988; Nass & Moon, 2000). Indeed, the results in Findings demonstrate that some EOD personnel assign names and personas to the familiar robots they use. The long-term implications of users assigning humanlike or animal-like traits to the robots is potentially exacerbated by the design of the robot (e.g., bi- or quadruped), behaviors (e.g., Natural Language Processing) and long-term proximity scenarios for increasingly collaborative human-robot tasks or mitigated by similar robot design, behavior, role and training choices.

Results in this work also hint at user variables such as operator age or group dynamics affect the tendency to humanize the robots. Therefore, further research into the human side of the equation must be done in order to better design robots that most effectively work with humans on tasks. As outlined in the first several chapters of this work, it is likely EOD will continue to work with robots in the near future. Thus, because of the continued human-robot cooperative scenarios in EOD work, these research findings can potentially be applied to the improvement of troop recruitment, selection and training as well.

APPENDIX A: RECRUITING MATERIAL

Postings on Facebook and LinkedIn Group pages

Subject: UW Research Study, Human-Robot Interaction

Hi! I'm a Ph.D. student at the University of Washington. Seeking study participants to collect demographic information and ask questions about robots used on the job, specifically about training and working with service robots. You may be eligible for this study if you: served in a branch of the U.S. military, trained to work with robots in the field and worked with robots in a military field setting over a period of time.

The study will last approximately 1 hour. Participants will be compensated $35. Contact me to sign-up or for more information: julie4@u.washington.edu.

Other Social Networking Sites Post Language

Research study: University of Washington. The purpose of this research is to better understand human-robot teamwork.

In this study, we will collect participant demographic information and ask questions about robots used on the job, specifically about training and working with service robots. The study will last approximately 1 hour. Participants will be compensated.

You may be eligible for this study if you:

- Served in a branch of the U.S. military.
- Trained to work with robots in the field.
- Worked with robots in a military field setting over a period of time.

You may not be eligible for this study if you:

- Only have experience with robots that are "drones," or fully autonomous robots.
- Only have experience with robots outside a military setting.

If you have any questions or are interested in participating, contact Julie Carpenter at julie4@u.washington.edu.

E-mail to Specific Individuals in a Social Networking Site

Subject: UW Research Study, Human-Robot Interaction

Dear [ ],

I ran across your name in [ ] on [ ] while searching for individuals who might have U.S. military experience using robots everyday. I am a Ph.D. student at the University of Washington in Seattle, and I am seeking participants for my dissertation research.

In this study, I will collect participant demographic information via questionnaire. Then, I'll ask some questions about your personal experiences using robots on the job. The study will last approximately 1 hour. Participants will receive $35 for participation.

Participation is voluntary and all responses will be kept strictly confidential. Please contact me with any questions. If you would like to learn more about my research, or me there is more information at: http://www.jgcarpenter.com/. I look forward to hearing from you.

E-mail to Colleague/Military Personnel Requesting Assistance

I would like to let you know about a research study that may be of interest to your colleagues and ask you to consider referring your colleagues for possible participation. The goal of this research is to provide a grounded understanding of how context of use, technology training, user expectations and human-robot teamwork situations can influence human-robot interactions and related outcomes of human-robot longitudinal teamwork.

In this study, we will collect participant demographic information via questionnaire about the participants. Then, via semi-structured interview, we will investigate participant perceptions about robots used on the job, specifically about training and working with service robots. The study will last approximately 1 hour. Participants will receive $35 for participation.

Colleagues that meet the following criteria may be eligible to participate:

- Served in a branch of the U.S. military.
- Trained to work with robots in the field.
- Worked with robots in a military field setting over a period of time.

Interested participants should have experience with robots that are not "drones," or fully autonomous robots.

We look forward to speaking with colleagues in your practice who may be interested in participating in this study. Please feel free to contact me with questions, or have your colleagues contact my research team using the contact information provided below.

Thank you for your time and consideration.

Letter of Cooperation from Colleagues/Military Personnel

To Whom It May Concern:

Julie Carpenter has requested permission to collect research data from colleagues, employees and associates of [Organization/Division]. I have been informed of the purposes of the study and the nature of the research procedures. I have also been given an opportunity to ask questions of the researcher.

The [Organization/Division] would like to cooperate with Julie Carpenter at the University of Washington in recruiting subjects for her research. We understand that the purpose of this study is to better understand how military personnel work with robots in the field.

In order to provide support to Ms. Carpenter, we will send a letter or email to colleagues, employees and associates asking for volunteers and stating that whether or not individuals participate in the study will not affect their relationship with [Organization/Division]. We understand that the interviews and surveys conducted by Ms.

Carpenter are confidential and that only she will have access to identifiable data. We will look forward to receiving the results of the study, when it is published.

As a representative of [Organization/Division], I am authorized to grant permission to have the researcher recruit research participants through our [Organization/Division].

If you have any questions, please contact me at (area code and phone number).

Sincerely,

<Name of Authorized Representative>

<Official Title>

Suggested Text for Interested Colleague/Military Personnel to E-Mail Potential Participants

I am writing to tell you about the research on human-robot teams being conducted by Julie Carpenter at the University of Washington.

The purpose of this research study to provide a grounded understanding of human-robot teamwork situations.

In this study, she will collect participant demographic information via questionnaire about the participants. Then, via semi-structured interview, she will investigate participant perceptions about robots used on the job, specifically about training and working with service robots. The study will last approximately 1 hour. Participants will receive $35 for participation.

You may be eligible for this study if you:

- Served in a branch of the U.S. military.
- Trained to work with robots in the field.
- Worked with robots in a military field setting over a period of time.

You may not be eligible for this study if you:

- Only have experience with robots that are “drones,” or fully autonomous robots.
- Only have experience with robots outside a military setting.

It is important to know that this letter is not to tell you to join this study. It is your decision. Your participation is voluntary. Whether or not you participate in this study will have no effect on your relationship with our organization.

If you are interested in learning more, please review the enclosed information and email Ms. Carpenter at julie4@u.washington.edu. In your email, indicate your name, your interest in participating in the study, and your contact information (phone number or e-mail). You can also call her at (area code and phone number).

You do not have to respond if you are not interested in this study. If you do not respond, no one will contact you, but you may receive another email, which you can simply disregard.

Thank you for your time and consideration.

Flyer with Tear Strips

The University of Washington LIFE Center is currently seeking participants to take part in a study about human-robot teams. The purpose of this research is to understand human-robot teamwork in order to design better robots.

If you choose to participate, you will answer general demographic information and talk one-on-one with a member of the LIFE Center about your personal experiences, specialized training and working with robots. The study will last approximately 1 hour. Participants will be compensated $35.

You may be eligible for this study if you:

- Served (or currently serve) in a branch of the U.S. military.
- Trained to work with robots in the field.
- Worked with robots in a military field setting over a period of time.

You may not be eligible for this study if you:

- Only have experience with robots that are “drones,” or fully autonomous robots.
- Only have experience with robots outside a military setting.

If you have any questions or are interested in participating, contact Julie Carpenter at julie4@u.washington.edu or (area code and phone number).

Oral Consent Script for Informed Consent (Skype and Telephone Interviews)

Hello, my name is Julie Carpenter. I am a graduate student at the University of Washington in the College of Education, and I am undertaking research that will be used in my dissertation.

I am studying human-robot teams. I would like to ask you a series of questions about yourself and your experiences with robots. I am very interested in your opinions and interpretations of robots in general.

The information you share with me will be of great value in helping me to complete this research project, the results of which could significantly enhance our understanding of these important situations. Although we hope the findings from this study benefit society, you may not directly benefit from taking part in the study.

This interview will take about an hour of your time.

There is a small risk of a breach of confidentiality, but all efforts will be made to keep everything you tell me in the strictest confidence. I will not link your name to anything you say in the text of my dissertation or any other publications.

There is also a risk that hearing these questions will make you feel uncomfortable. Some people feel that providing information for research is an invasion of privacy.

Participation is voluntary. If you decide not to participate, there will be no penalty or loss of benefits to which you are otherwise entitled. You can, of course, decline to answer any question, as well as to stop participating at any time.

If you have any additional questions concerning this research or your participation in it, please feel free to contact me, my dissertation supervisor or our university research office at any time.

You will receive $35.00 for participating in this study. You will receive a check in the mail within two weeks of your participation in the study. In order to send you a check for your participation in this study, we will collect your name and mailing address. This information will be used only for UW accounting purposes. We will not associate this information with study data. Please note that should you receive $600 or more for participation in University of Washington research studies, then the amount you have been paid gets reported to the IRS as income.

Do you have any questions about this research? Do you agree to participate?

If so, let's begin….

APPENDIX B: DEMOGRAPHIC QUESTIONNAIRE

1. Age: _______________

2. Gender (circle one): Female Male

3. Formal education (check all that apply):

   High school

   Some college

   College graduate

   Some graduate school

   Master's degree

   Doctoral degree

   Professional degree

   Other ___________________________

4. Previous experience with robots/robotics before military service (check all that apply):

   None

   SciFi (books, movies)

   Toys

   Home Kits/Hobby

   Publicly available robots (museums, etc.)

   Professional research and development on robots

   Education (classes, research or other academic experience)

   Other ___________________________

5. Military branch you served in (check all that apply):

   Army

   Navy

   Marines

   Air Force

   Coast Guard

   National Guard

6. Total number of years in military served:
7. Age when you enlisted:
8. Age when re-enlisted (if applicable):
9. Military rank (current or when discharged):
10. Special Forces or Elite Unit membership (Rangers, ReCon, SEALs, etc.), if applicable:
11. If you have worked on or with robots before your military service, please describe the conditions (industrial robots, humanoid robots, work, school, etc.).
12. In your own words, what is a robot?

APPENDIX C: SEMI-GUIDED INTERVIEW QUESTIONS

1. Tell me about your job in the military.
2. What were/are the major challenges that you faced in this role on a daily basis?
3. What skills, training, or formal preparation did you require (beyond basic training) for your job?
4. Tell me specifically about your training for working with robots on the job.
5. What do you think of the training you had?
6. Tell me about your experiences or thoughts about robots before this job.
7. This question may be difficult to respond to with certainty, but I'd like to get your thoughts on it. In thinking about how you changed during your military service, how much did your feelings about working with robots change compared with your ideas about working with humans?
8. If I followed you throughout a day in the field working with a robot, what would I see you doing?
9. How were team tasks/responsibilities divided between you and the robot(s)?
10. Tell me a story that sticks out in your mind about working with robots in the field.
11. How do you feel about the robot you worked with the longest?
12. Tell me in your own words: what is a robot?

APPENDIX D: VERBATIM PARTICIPANT DEFINITIONS OF A “ROBOT”

NAME	QUESTIONNAIRE	INTERVIEW
Aaron	A machine with multiple functions operating either autonomously or under remote control, not just a vehicle.	It’s basically a machine that can perform multiple functions, you know, not just a single function device either autonomously on its own or when its programmed to go do something or with direct control of a person who’s not sitting there physically touching it, with either a radio controller or whatnot. Where you’re sitting there with a controller and it’s off somewhere else doing its thing.
Brady	A complex tool used by humans to achieve required results.	In simple words, it’s a tool. A very, very important tool. It’s complex and there’s wires and circuits and cameras and all that, but when it comes down to it, it’s just a tool. The tool we use the most, and very expensive, but it’s a tool.
Irving	Any system which through direct human control, semiautonomous, or fully autonomous function, perform a function, service or action through electromechanical movement.	Something that performs through electro-mechanical function, um, performs some type of movement, some type of function, be it…I’m gonna quote myself a little…either through direct human control, autonomous or semiautonomous control basically to either mimic a human behavior or to perform a designed action.
Sarah	A remote tool.	I said just basically it was a remote tool…to be able to render a bomb safe or to dispose of it with remote capabilities. Keeping, you know, all persons at as much distance as possible, as its capabilities will allow.
Jeremy	For EOD purposes, it's a tool we use to control remotely to recon, video, manipulate, place tools, etc., on IEDs or suspicious items in lieu of sending a bomb technician down to investigate.	It’s a….for EOD purposes…..it’s a tool we use to perform remote reconnaissance, manipulation of devices, to investigate unknown items, and to place tools, demo charges, using that, from a remote distance.

Hector	Motorized mechanical human controlled or programmed tool.	I guess there's a lot of different types of robots. It's a machine. It doesn't make its own decisions. It's either directly controlled or it could be programmed to do a certain job. Usually they move about in some form but not all of 'em. I don't know. I was a . . . I used to work at [redacted] in [redacted], and we had robotic painters. And so those, they moved an arm, but they didn't roll around or anything. So they were robots and nobody controlled 'em directly but they had a computer program that controlled 'em. So I consider those robots, too. I guess that's kinda hard to put into words.
Marshall	A tool to complete a mission which prevents me from taking a risk myself.	I really think of the robot as a tool and an extension that I could-, it's a tool that allows me to do my job, and not take particular risks. OK? I mean, my robot, it was very-, very important to me. My most important tool because it gives me the thing I need the most when I operate and that is distance. I mean, if I can disarm that bomb or at least figure out, even if I can't get to it or disarm it with the robot, I have much better situational aware-, awareness after running it down, seeing it and then when I've put on the bomb suit, I can . . . I can get down there and I'm much less likely to get killed if I know what's down on the ground before I actually have to go see it with my own eyes. The ro-, it's an extension of yourself that when you become a good operator with a robot, it's . . . it's out there and it's doin' things and you know, as a team leader I used to love it. It'd be like [laughs] drive it down there, do it, boom. Yay, I don't have to put the bomb suit on. Cool [laughs]. You know. Your operator, on the other hand, he's the guy that's gotta clean it, take care of it, fix it, put it together, you know, yeah, those types of things. But I . . . I love the robot. I think it's imperative. I think it's the greatest tool ever made for EOD operations.

Omar	Electro-mechanical device generally used to perform repetitive, dangerous or remote operations autonomously or under human guidance (or anywhere in between).	Basically, it's a mechanical extension to being something that . . . either because it's too repetitive, or too dangerous, that a human would normally do. It's kind of a labor-saving device. It's not directly connected to you like a Waldo would be, you know, where it replicates your gestures, but it could either be autonomous or-, or completely remote controlled, depending on the function. For bomb techs, of course, we want-, we like having some autonomous functions but we-, none of those autonomous functions are ones we want to start without us directing it. You know, talking to the [company redacted] guys and heavy engineers out in-, at many of our exercises, they wanna see how to build the product and they ask about, 'Well, you know, what if you-, what if you did this or that?' And, you know, one of the things that we've said is that, 'I don't care if the thing flips over; I don't want it trained to set itself upright without me telling it to.' You know, it's great that it has the function that it'll automatically do that but . . . if I don't tell it to do that, I don't want it to do it.
Wade	A remote-controlled machine that is controlled in some manner by a operator. It has some form of programmed or preset movements.	To me, it's some sort of remote-control machine that, it's gonna have programming, and so it has set functions, so both PackBot and TALON are perfect examples. There's three sets, so if you want it to go into…I mean, if you want to recall the arm to its stowed position, I think the PackBot has a lot more as far as that because you can go into search modes and it automatically configures itself to what someone has decided is the best setup for that, or put it in travel mode. I don't think it'll brake itself yet..that's still, you have to learn how to do that with it. It's a type of machine, like I said, remote control that will have set programming so that you can say, do this, and it will do what you want it to do. It's either the radio controlled or tethered like our fiber optics.
Roy	A robot to me is an electronic or mechanical device.	A robot is a capable tool that allow you to do things from a remote position without exposing yourself to a hazard.

Simon	There are two definitions. One is it's a . . . oh, what would you say? It's a mechanical invention designed to make our lives easier and safer. The other one is . . . it's an extension of our own-, of our own personality. As they have to take on personality after you've used them for a while.	It's a mechanical invention designed to make our lives easier and safer. That's the main thing. And sometimes, it can be an extension of our own personality.
Isaiah	A mechanical tool that's used for many different purposes. It's being controlled by the most part; it can be controlled by a human.	Ah, so it's, to me, it would be, you know, a tool, which you know, any person, I mean, utilized to, you know, accomplish a specific task. I mean, could be used to entertain . . . but, I mean, and it means, specifically in my experience, it's a tool that's utilized to keep, you know, the humans, you know, in a safe harbor. A very effective one, you know, which again, in the combat environment.
Jed	A robot is a mechanical...let's see…I'd say it's a tool that allows an operator to do something from a distance.	A robot is a capable tool that allow you to do things from a remote position without exposing yourself to a hazard.
Reynaldo	Well, I guess, in my own words, it would just be, to me, it's . . . a-, a tool used to accomplish, you know, a task . . . for an EOD technician . . . in a ha-, in a very hazardous or imminent threat situation.	A robot is just a . . . a robot is a tool used, which really it, it's a tool for an EOD technician to use in a situation where there's an imminent threat, a high probability of a-, a detonation from an IED. It's a tool that he can use to remotely dispose of or RSP an IED. It's another tool…. [laughs] to render safe.
Ben	A robot is a computerized machine or tool, I should say I guess, that when utilized with human interaction perform different maneuvers, tasks, accomplish goals, and everything dangerous when being controlled by a human.	It's just a machine, it's a tool, you know, that has a interface that has to have a human component mixed in with it in order to operate. I mean, in my instance, the use of word and how we use robots in EOD that was the nature of the thing now, I mean. There's other, you know, other definitions of robots. There's the sci-fi ones, the ones that they're developing in Japan right now, there's toy dog robots that, you know, for all intensive purposes I guess, really don't need any kind of human interaction, whereas as we used it…as we used them and everything, it was a computerized machine that required human interface that allowed us to accomplish a specific goal with ourselves staying somewhat safe.

Leon	It's a tool.	A tool.
Rashad	A robot is a tool that humans operate.	I would say a mechanical, generally speaking, electronic and usually powered by a battery device that is normally used to accomplish some kind of mechanical task. But I'd also add to that, it could also just be used for . . . auditory or visual acquiring. I don't think that would have been defined in my previous definition. You could just use a robot for a camera and the microphone. That'd be useful.
Quinn	A robot is a mechanical device with human interface that assists us in menial and / or dangerous tasks under direct supervision and control, you know, of the human operator.	It's a mechanical tool that is controlled by a human to do menial tasks and/or dangerous tasks to help alleviate the dangers of the human interface, i.e. put the mechanical piece of equipment downrange under direct supervision and control of the human.
Marcus	An electro-mechanical system that is either pre-programmed for a set of tasks, or controlled by people in order to help people.	A robot is an electro mechanical device that is utilized to help human beings to perform some kind of work or duty.
Mino	A robot is a device that's typically on battery that's wired, or usually wired, to a controlling unit that's controlled by a person or a human.	A robot's a tracked, battery-operated device that's operated by a human off of either a wireless or wired communication.
Connor	A robot is a remote platform designed to accomplish tasks from a remote location.	It's a system that allows you to accomplish tasks from a distance without putting boots near it. It's just a remote system to accomplish the same tasks, but safer.
David	A robot, overly extension of a, of my personal-, of my hands. The robot is a tool that we use, well, it's an amazing tool. It keeps-, it keeps us safe. Just . . . it's not very-, it can't work on its own, obviously, but it basically, if you could have the best robot in the world that can do anything and everything. But if you don't have an operator who is knowledgeable and who is trained on that piece of equipment, then that robot-, the robotics is pretty much obsolete.	Yeah, like I said before, it's just an extension of my hands. It's a tool we use and to keep people safe.
Axel	A robot's a machine that performs a task, but it's controlled by a human.	It's a machine that requires human input to accomplish a task.

APPENDIX E: US NAVY EOD ETHOS

I am a United States Navy EOD Technician, a warrior, professional Sailor and guardian of life.

I willfully accept the danger of my chosen profession and will accomplish all duties my great country asks of me.

I follow in the wake of those who have served before me with uncommon valor. I was born from the bombs and mines of the Blitzkrieg. I have cleared the world's sea lanes, and fought in the jungles, deserts, and mountains around the globe.

I will never disgrace the Navy EOD Warriors of the past and will uphold their honor and memory, both on and off the battlefield.

I am a quiet professional! I strive to excel in every art and artifice of war. I adapt to every situation and will overcome all obstacles. I will never fail those who depend on me.

I maintain my mind, body, and equipment in the highest state of readiness that is worthy of the most elite warrior.

I will defeat my enemies' spirit because my spirit is stronger. I will defeat my enemies' weapons because I know my enemies' weapons better.

I will complete every mission with honor, courage, and commitment. Though I may be alone and completely isolated, I will trust my teammates and my country. I will never give up and I will never surrender.

Where most strive and train to get it right, I will relentlessly train so I never get it wrong.

I am a United States Navy EOD Technician.

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VITA

Julie Carpenter was born in Madison, Wisconsin. She has also lived in Philadelphia, Pennsylvania and Seattle, Washington and enjoyed the advantages of both cities, including living close to seashores and mountains.

She earned her Bachelor's degree in Communications from the University of Wisconsin-Madison, a Master of Science in Technical Communication and a certificate in Human-Computer Interaction from Rensselaer Polytechnic Institute, and a Master of Science in Technical Communication from the University of Washington. Her work focuses on user expectations and attachment to robots, especially in field applications (e.g., space exploration, defense, and humanitarian relief efforts) in order to aid the development of robots that are effective in human collaborative/team or training situations. Long-term, this research can be used to help improve robotics training, enhance robot development specifications to mitigate mission- dependent risk, and improve warfighter and civilian safety in conflict environments, both foreign and domestic.

Prior to her years in higher education, she worked many years in the independent music business promoting new music and musicians in ways most accessible to fans. Carpenter continues supporting new music through her ongoing role at an independent record label based in Minneapolis, MN. In her spare time, she enjoys reading, travel, baking, gardening, attending live music events, and the company of her close friends and many pets. She currently resides in Portland, Oregon.