COGS 100 Winter 2022, Assignment 1
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Analysis of Interactive Navigational Strategies

For our navigational task, we chose the directional challenge of crossing the street. For many people who are blind or visually impaired, crossing the street is a source of contention. People who experience total blindness, for example, often find themselves veering off the pedestrian path, which can lead to fatal consequences. Despite this, crossing the street is a common and unavoidable part of daily life. The goal of this paper is to identify three challenges associated with crossing the street without vision, examine the interactive strategies currently employed in order to address those challenges, and finally, design a new navigational tool that improves upon the white cane.

Most blind people rely on white canes in order to help with daily navigation. White canes are an assistive mobility device characterized by a long white body that allows its user to gain tactile feedback from their surroundings. Through active use, the white cane becomes an extension of the user's cognition and body schema (Maravita and Iriki, 2004). Furthermore, the easily recognizable white cane serves the additional purpose of signifying to the surrounding environment that the user is visually impaired. More than a cognitive artifact, the white cane is also an environmental representation of blindness.

We used low fidelity imitations of white canes in order to perform our navigational task. We employed a long umbrella and a mop to emulate navigational strategies common to the white cane.

We crossed the street blindfolded in a quiet but busy neighborhood. Due to a constant influx of cars, trucks, pedestrians, pets, and children, it is an ever-changing environment. We begin our task at Point A, move to Point B, and turn around to retreat back to Point A. **[Figure 1]**

Our planned route is highlighted in red **[Figure 2]**, but in practice we frequently veered off into the blue route due to the navigational challenges we faced.

Figure 1: Point A and Point B

Figure 2: red route and blue route

1. Lost sense of direction

When crossing the street blindfolded, we were surprised to see how quickly we lost our sense of direction. Contrary to our expectations, walking in a straight line without vision was surprisingly difficult. After a few steps, we would begin to walk diagonally and deviate from our expected path.

We would learn we diverged from our expected path when our emulated canes make contact with an unexpected object. For us, this usually meant hitting our canes against the tires of a parked car, or whacking the bottom of a non-sloped curb. **[Figure 3]** This feedback was incredibly disorienting; it told us we weren't where we thought we were. One of the views of embodied cognition is that cognition is time pressured (Wilson, 2002). Time-sensitive pressures within our environment (incoming vehicles) force us to quickly re-evaluate where we are and get to safety.

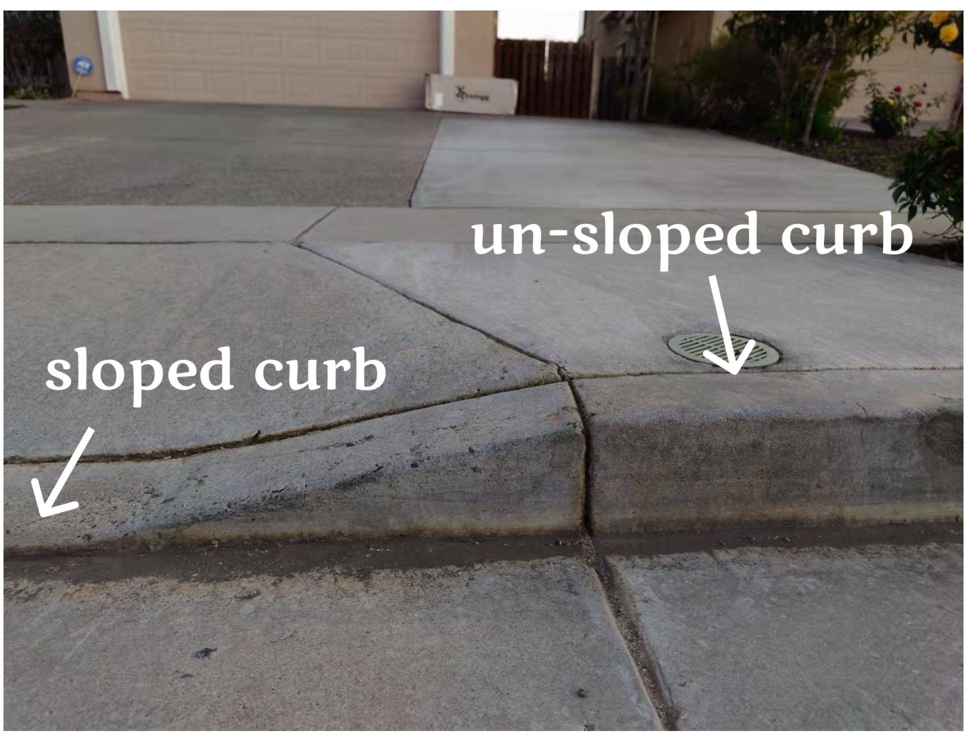

Figure 3: sloped vs un-sloped curb

Losing one's sense of direction when crossing the street is commonly experienced by people with total blindness, and can have fatal consequences. However, there are interactive strategies that we may use in order to handle this problem. First, we use our white cane to gather as much tactile feedback as possible to reorient ourselves within our immediate environment. We can no longer make assumptions on where we are; we must rely on active sensing. What is around us? Is it a parked car, a curb, a bike, or something else? Figuring this out can clue us in on where we are located. For example, a parked car is likely to be parked parallel to a curb. Next, we sweep the cane back and forth in search of a curb. Sidewalks are almost always one step above the street, so stepping over a curb puts us back at safety. If we are unable to find a curb, we must choose a direction to walk in hopes it will bring us closer to the end of the street. If we have completely lost our sense of direction, we must rely on auditory cues. If we hear incoming traffic (the sound of an engine getting louder and louder), we should move in a direction perpendicular to that sound. However, if we hear the sound of multiple cars driving quickly past us and feel the wind as they pass by, we can assume that they're driving parallel to us, and it would be safe to also move in a similar direction.

2. Drop curbs: unexpectable and easy to miss

Street curbs, especially the unsloped ones, are another source of danger. For the visually impaired, detecting incoming curbs can be difficult. The consequences of tripping over an unexpected curb has the potential to be deadly.

To a blind person who actively perceives with a white cane, any situation beyond the reach of the cane tip is unavailable. A person with sight can foresee an upcoming curb easily, and mentally get ready for the drop-off. Yet such preparation is impossible for the blind. When a curb is finally noticed, it is usually very close. This leaves the blind person, who is in an inertia of moving forward, barely any time to respond to the drop-off at their very next step.

We noticed in our trials that curbs going down (ie. off the sidewalk into the street) are much harder to detect than curbs rising up (ie. off the street onto the sidewalk). This is because the holding angle of a white cane allows it to be stopped by a rising obstacle, but makes it subject to slipping off and missing a drop-off **[Figure. 4]**. As a result, instead of tripping onto the sidewalk after crossing a street, a blind person is more likely to trip into traffic, which is even more dangerous.

To deal with the fatal drop curbs, we find the constant contact technique most helpful. The constant contact technique is a common navigational tactic used by users of the white cane. (Kim et al., 2009) It involves keeping the cane tip in contact with the ground as it sweeps back and forth. Each time we step one foot forward, we sweep the white cane to the opposite side of our body. This way the white cane doesn't interfere with our current step, and is always probing for a safe spot to land our next step. "Constant contact" and the "sweeping movement" are the keys to this interactive strategy.

Alva Noë (2004) once stated that “Your tactile impression…consists not in the sensations in your hands and feet, but in the way those sensations result from attentive movement through the space.” Using the constant contact strategy, a blind person traces the surface of the ground to gain a mental image of its shape. When the tip of the cane falls in height, the person retrieves from prior knowledge this indicates a drop-off ahead, so they get prepared mentally and physically.

Sloped curbs posed less of an issue compared to the un-sloped curbs. In the cases that we were able to follow a sloped curb into the street **[Figure 4]**, we didn't feel any obvious drop-off on the ground and thus were less likely to trip. The smooth slope downwards also worked as an indicator that we were about to enter a street, and served as tactile feedback that we were about to enter the street.

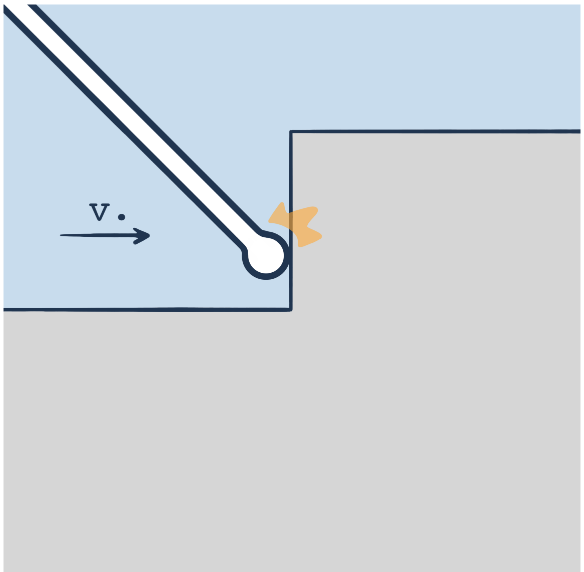

Figure 4.1: rising curb stops your cane

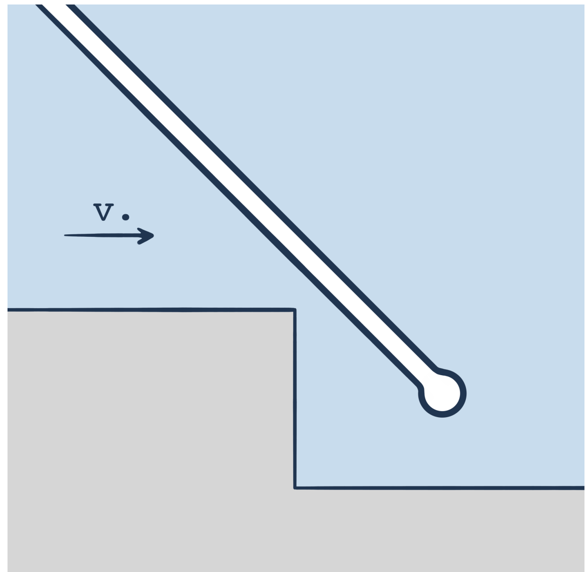

Figure 4.2: cane could slip off a drop curb

3. Traffic: unpredictable and ever-changing

The complex and ever-changing environment in the street is also a source of frustration and uncertainty for the blind and visually impaired. Even on a familiar road, traffic volume and parking conditions can differ dramatically in a day. For example, one day you might find a car completely blocking your expected path. Or, you might bump into a trash can carelessly left on the street by your neighbor. **[Figure 5]**

Figure 5: unexpected obstacle (car blocking the way)

Those who depend on white cane to navigate the world have a slower umwelt than the sighted. While people with vision can capture a wide range of information in a snap and react quickly to changes in the environment, blind people "[perceive the] space by touch, not all at once, but through time" (Noë, 2004). In other words, blind people receive less feedback from the environment at each point of time. We can argue that blind people have a lower "degree of embodiment" (Dawson, 1994) in terms of a time-pressured environment. However, a busy street is a time-pressured situation that requires fast-pace information-processing. When the rate of change outpaces the ability of a blind person to perceive the world, they can get confused.

There is little that we can do with the white cane alone to solve this problem, but with the help of auditory input, we can improve our chance to cross an ever-changing street. At a cross, hearing parallel traffic is a signal that it is safe to walk (Naqui, 2021). After entering a street, we can use wider sweeping motion to detect a larger range around our body and avoid vehicles from the side. We can combine sounds that we hear and vibration from the cane tip to identify an upcoming car.

Redesign

We propose the Taylor-Morgan-Buryuk Cane (hereby shortened to the TMB Cane), a cybernetic navigational system composed of a pair of smart glasses and an enhanced white cane! [Figure 6, 7, 8]

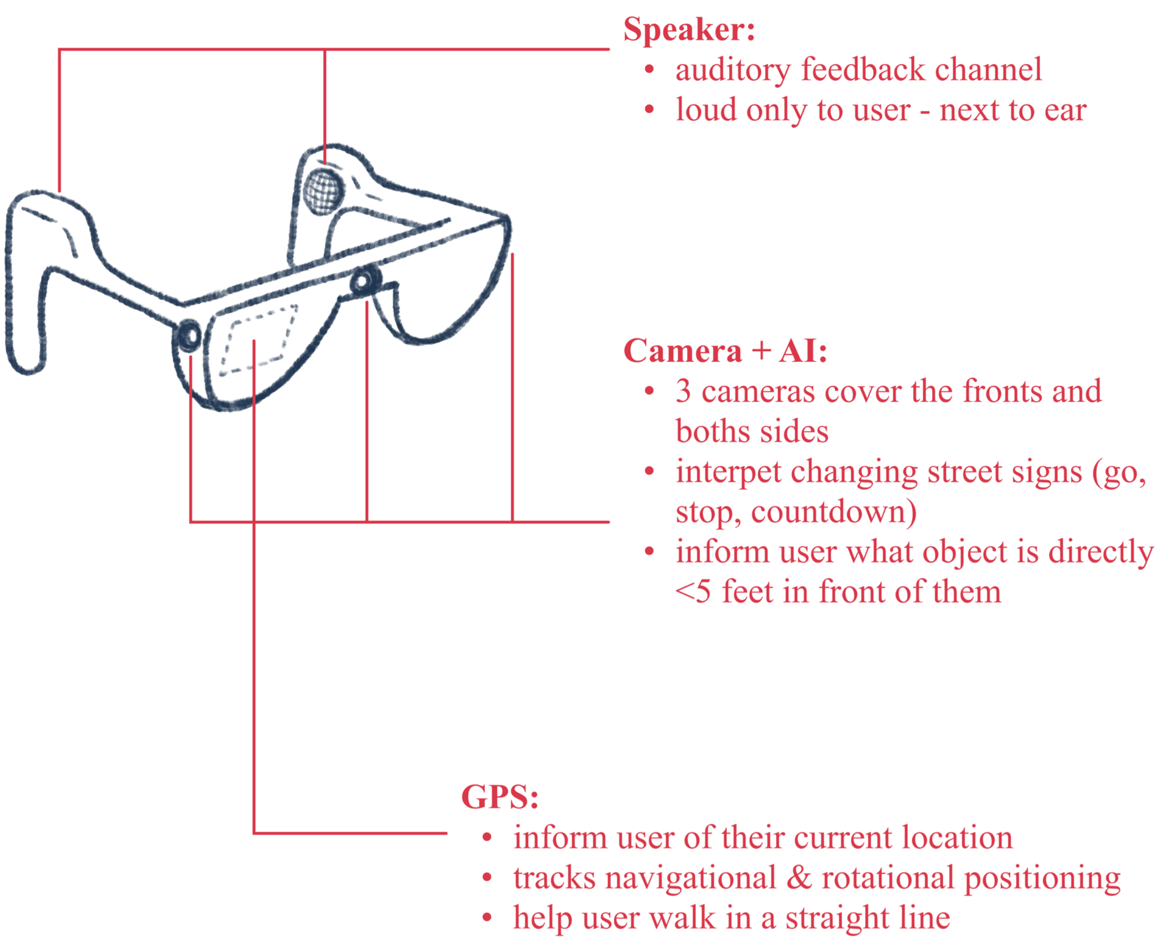

Figure 6: how the smart glasses work

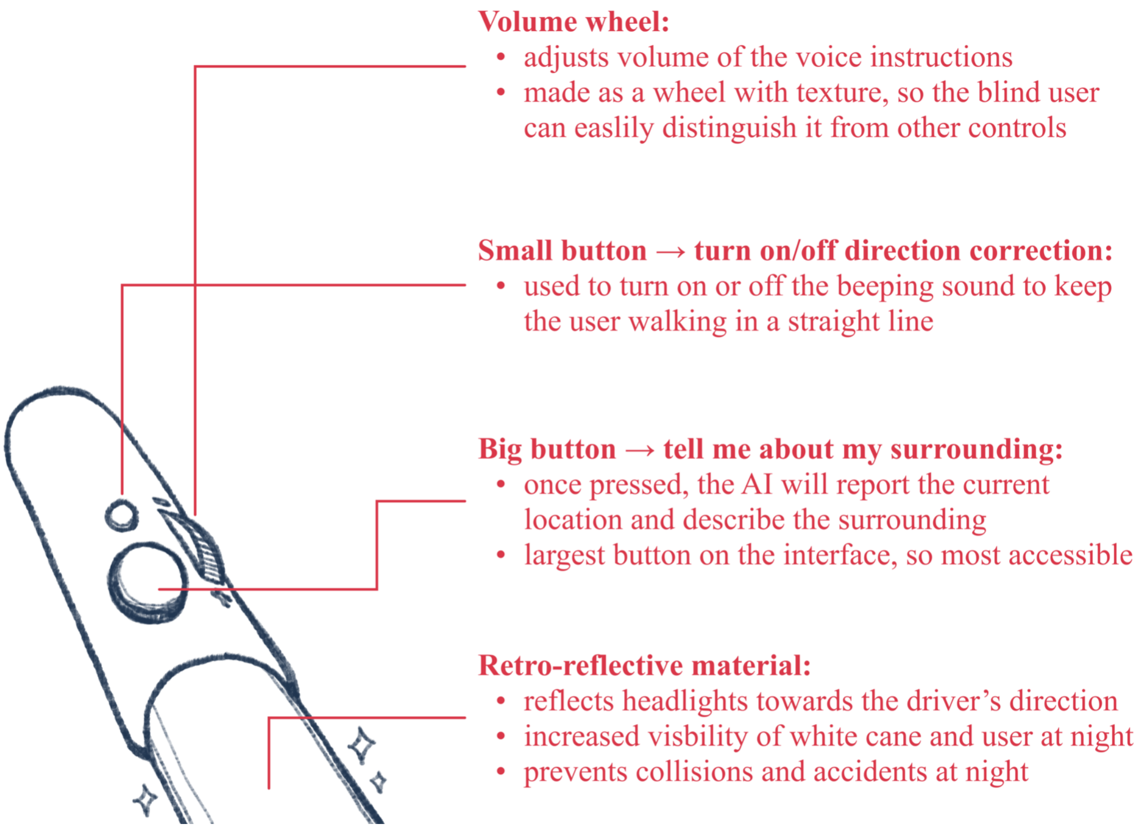

Figure 7: how the control on the cane handle works

The TMB Cane was designed with the purpose of helping to prevent blind people from losing their sense of direction. The smart glasses are embedded with a GPS, three cameras, a speaker, and an AI computer chip. The AI will use image recognition in real-time to identify and interpret objects of interest. It will then inform the user through an auditory channel located on the arms of the glasses. Due to the speaker's proximity to the user's ears, we can ensure clear and loud auditory feedback. Our enhanced white cane is now outfitted with buttons on the side of the cane, near the grip. These buttons control the smart glasses; they can adjust the volume of the speakers, read aloud your current GPS location and its current battery life, and enable the usage of temporarily helpful features such as rotational awareness. Additionally, the white cane is modified with the addition of a retro-reflective surface, to increase visibility at night and minimize accidents.

Let's examine a scenario where a blind person, Tom, uses the TMB Cane to cross a street. Due to a weak sense of direction, Tom starts to turn slightly to his right and walks diagonally across the street. The GPS detects his tilted trail, and the camera senses that he is no longer facing the sidewalk. So the AI alerts him, "beep, beep" with a soft sound coming from the speakers on his glasses. Tom immediately realizes that he is leaning to the right, so he adjusts his walking rotation until the beeping stops. Now he walks straight to the sidewalk and safely steps onto the sloped curb. Tom is confident that this is the right track to his destination, because at every cross, the smart glasses will read out the street signs. Additionally, if he feels confused, he can press a button on his enhanced white cane. The GPS embedded within his smart glasses reports, "Bank of America at your left, a narrow two-way street on your right." It is almost dark, but Tom is not worried, because he knows his TMB Cane has a retro-reflective surface. At night, the cane body will glow by reflecting the headlights of cars. This increases his visibility, and thus, his safety.

We hope Tom enjoys his TMB Cane!

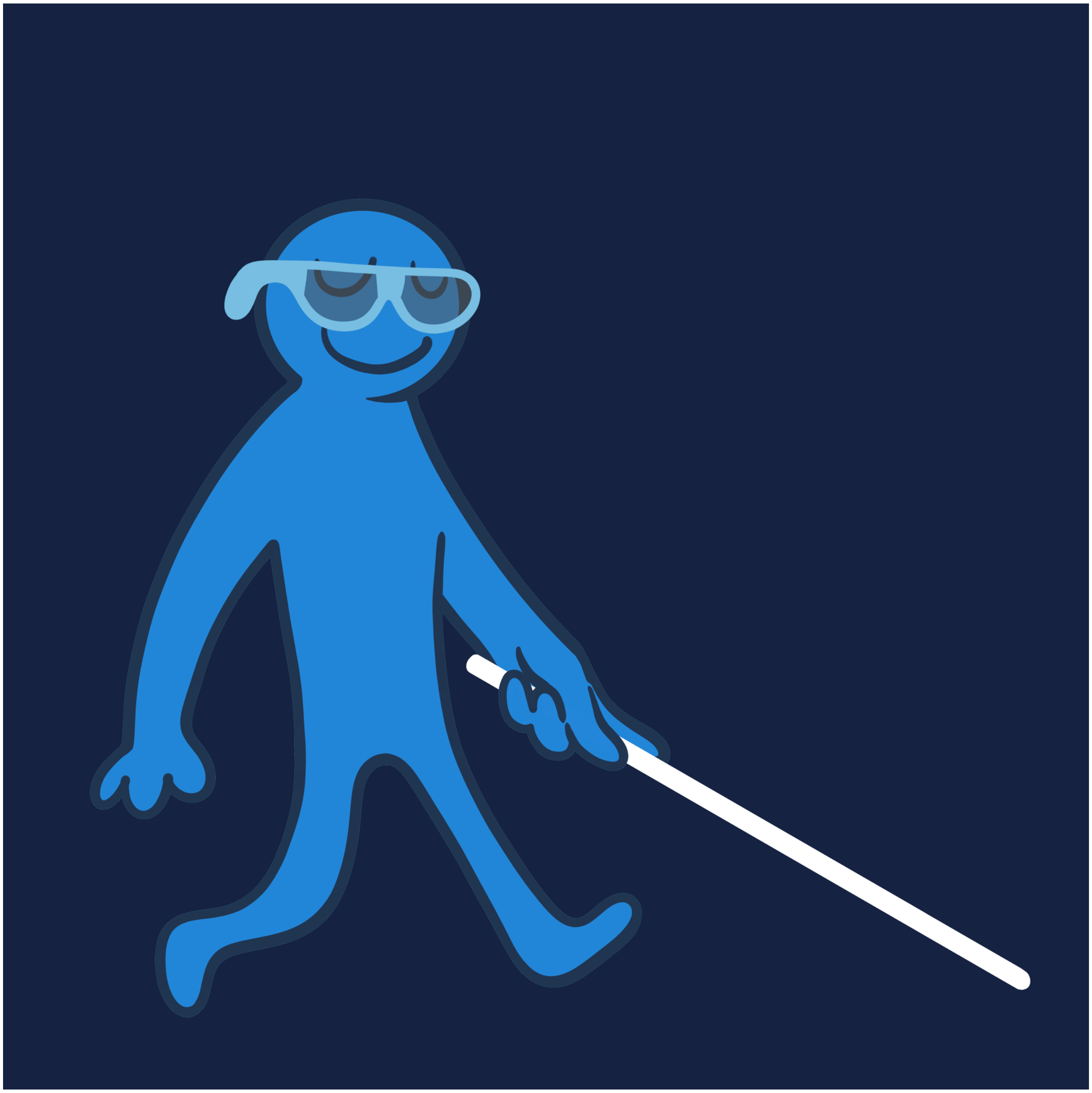

Figure 8: Tom walking with his reflective TMB Cane

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Works Cited

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