# How Virtual Work Environments Convey Perceptual Cues to Foster Shared Intentionality During Covid-19 for Blind and Partially Sighted Employees

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# Abstract

The Covid-19 pandemic altered workplaces. For those with ‘office jobs,’ this meant working ‘virtually,’ or remotely, from home. This transition forced organizations and workplaces to exercise flexibility, adapt workflows and rely on Information and Communication Technologies (ICTs) to work remotely. However, Blind and Partially Sighted Individuals (BPSI) face challenges accessing work digitally, setting up their home offices, financing assistive devices, equipment and software, remote communications and employer support (Ginley, 2020). In response, with the Canadian National Institute for the Blind (CNIB), this Major Research Project (MRP) reports on the results of a longitudinal participatory design study investigating the impact of working and training over a distance for BPSI. This study found evidence of assumptions about BPSI, stigma, how effectively ICTs transmit perceptual cues and a physical environment bias where accessibility practices defaulted to the brick-and-mortar workspace. What emerged is a model to assist in understanding how ICTs synchronize experiences for the construction of shared intentionality in virtual work environments. Shared intentionality, the capacity to engage with others in cooperative activities with joint goals and intentions (Tomasello, 2005; Schweikard and Schmid, 2020), was a powerful way to interpret the disparities that BPSI faced as a result of the physical-to-virtual work environment transition. The model is composed of three dimensions: *Spatial-topological synchrony* is the degree to which spatial perceptual cues, such as through video, spatial audio, or haptics, offer implicit cues, such as gestures, body location, or visual-spatial representations (e.g. diagrams); *temporal synchrony* is the degree to which real-time interactions clarify intentions; *mutual knowledge* is the degree to which diverse perspectives facilitate the joint construction of new knowledge and practices. The implications of this model could be significant, as it aids understanding what is lost and gained when transitioning to virtual work environments; this could inform the design of ICTs, organizational policies, training and education, and culture shifts in the workplace in regards to accessibility.

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# Table of contents

# List of figures

# 1.0 Introduction

## 1.1 Project background and purpose

The virtual and remote work transition that resulted from the Covid-19 pandemic altered the way that people work. The abrupt transition forced organizations and workplaces to exercise flexibility, adapt workflows and rely on Information and Communication Technologies (ICTs) that play a critical role in enabling people to work from home. However, inaccessible interfaces and digital platforms are major barriers for Blind and Partially Sighted Individuals (BPSI) to engage in virtual work. In particular, BPSI face issues related to digital accessibility, home office set up, financing assistive devices, equipment, software, remote communications and employer support (Ginley, 2020). In order to identify the impact of the Covid-19 pandemic on adults with visual impairments who are of working age or are working already, to provide context, this study presents results from the Canadian National Institute for the Blind's (CNIB) Covid-19 Impact Survey (herein referred to as 'CNIB's Covid-19 survey')[1]. CNIB's Covid-19 survey found that 86% of respondents reported that their employer introduced new technology tools to facilitate working from home. Furthermore, 50% reported that they were experiencing accessibility problems with the technology tools needed to use for their jobs (CNIB, 2020)[2]. This Major Research Project (MRP) reports on the results of a longitudinal participatory design study that involved a multi-stage research project consisting of semi-structured interviews, observational research and co-design sessions to investigate the impact of working and training over a distance for BPSI. This study was conducted in partnership with the Canadian National Institute for the Blind (CNIB). Previewing the results, this MRP proposes a model for better understanding the impact of transitioning to virtual work environments. Two major concepts which underpin this model will now be introduced.

[1] The Covid-19 Impact Survey findings presented in section 1.0 of this MRP includes respondents who identified that they have employment concerns and would answer the questions.

[2] The findings from this survey have not been made publicly available by CNIB at this time. Shared with this student investigator via a personal communication, April 20, 2021.

The first concept is shared intentionality, an area of research and philosophical inquiry since ancient times, and across many disciplines, which is the capacity to engage with others in cooperative activities with joint goals and intentions (Tomasello, 2005; Schweikard and Schmid, 2020). Shared intentionality is prevalent in our lives, for example, it is what motivates two or more individuals to raise a child, compete in team sports, play in an orchestra or work in an office. It can also be demonstrated in our everyday actions, for instance, stopping at an intersection with another car that is flashing their turn signal. In this situation the other car signals a left turn, this light flashing is enough of an implicit statement for you to assume the intention to turn left and therefore understanding the goal of the interaction. For this reason, you wait for them to turn before proceeding.

The second concept is how spatial and topological properties of everyday interactions, such as gestures, facial expressions, pictures, diagrams or schematics are or are not conveyed through ICTs in an accessible way, as they might be in a real-world synchronous situation. For example, consider a scenario where you decide to stop by your manager's office to discuss a task with them. When you arrive, their posture, affect, tone and disarray of objects in the room, allow you to infer that they may be stressed, and it may not be the best time to discuss something with them. These spatial and topological properties of the physical environment (the light reflecting from the objects and people in the office), communication (implicitly) when perceived inform your understanding during your interaction in ways that would be unavailable if you only had access to what is explicitly stated (through spoken language, or via a text chat, for example). This, for instance, could allow you to more effectively infer how the person may perceive the information that you are sharing. These spatial or topological properties are sometimes conveyed in varying ways through ICTs. Videoconferencing, for example, provides *some* access to spatial and topological properties that provide the types of implicit information otherwise experienced in a physical environment. In the absence of implicit spatial and topological properties, people may rely on what is embedded in their individual minds to infer the intention of others. A problem arises when what is embedded in an individual mind, but not informed through implicit spatial and topological properties from the actual situation, causes someone to infer an intention that is far out of alignment relative to what was intended by their colleague. In this study, this inclination to infer the intentions of others is interpreted as how stereotypes and assumptions can

be formed. Barsalou (2009) describes this defaulting to inference as simulating with "perceptual, motor, introspective states acquired during experience with the world, body and mind" (Barsalou, 2009). In this study, how ICTs facilitate the transmission of spatial and topological properties of synchronous interactions, as well as the representations afforded by mutual knowledge will herein be referred to as *synchronization of experience*.

This investigation found evidence of varying levels of synchronization of experience in interactions in the virtual and remote workplace, these scenarios involved assumptions about BPSI, stigma, how effectively technology supports accessible work and a bias towards decision making in physical environments. Shared intentionality and synchronization of experience were found to be a powerful way to interpret these disparities that BPSI face in the virtual and remote workplace. This study's purpose is to propose a model to explain varying levels of synchronization of experience and the impact on shared intentionality in virtual work environments. The implications of this model could be significant, as it could inform the design of ICTs, organizational policies, training and education, as well as culture shifts in the workplace in regards to accessibility.

## 1.2 Context

This section provides an overview that identifies the challenges that BPSI face in the virtual and remote workplace and situates the problem space in which this MRP seeks to make an impact. CNIB's Covid-19 survey found that 49% of respondents had concerns about their employment as a result of the pandemic (CNIB, 2020)[2]. While some BPSI were successfully working from home prior to the pandemic, many found that this transition introduced a number of barriers and accessibility challenges (Ginley, 2020). These challenges centered around digital accessibility, social interactions, work from home set ups and management in the virtual and remote work environment.

Digital accessibility was a barrier prior to the pandemic, however the rapid transition to working from home further amplified these issues. Technology inaccessibility was found to be a source of stress for BPSI that could impact job retention (Crudden, 2002). Furthermore,

equipment and software were also found to be a challenge as many organizations relied on ICTs to enable their employees to communicate and work together. CNIB's Covid-19 survey found that 46% of respondents of the entire study[3] reported that training on how to use new technology tools was provided and 46% agreed that the training they received was accessible to them (CNIB, 2020)[2]. This study found evidence of cognitive load issues related to using multiple platforms, this could be attributed to the amount of working memory related to interoperability of assistive devices and ICTs. BPSI have identified the 'invisible work of accessibility,' which includes tasks that are not directly related to the work, yet significantly add to the mental load of the individual (Branham & Kane, 2015).

Social interactions in the workplace were also found to be impacted by the transition to virtual work environments. Prior to the pandemic, social inclusion was found to be a major challenge for BPSI that impedes access to and retention of employment (Naraine & Lindsay, 2011). This MRP found a 'leveling of the playing field effect' where physical distancing measures caused everyone to work virtually and remotely and BPSI were not the only group marginalized by issues of digital accessibility. Also, the physical space, or work from home setup, was found to be a barrier. In the office, IT specialists at the organization are able to provide and setup the devices and internet access BPSI require, however at home depending on the individual's degree of sight loss setting up this equipment can be challenging (Ginley, 2020).

There is an urgent need to better understand the impact of the virtual and remote work transition for BPSI. Particularly in the current digital age, where ICTs are intrinsically visually biased and as a result BPSI have become "arguably the marginalized group most drastically affected" (Chaudhry, 2005, as cited in Llouquet, 2017). Engaging the digital economy has become an issue of accessibility for BPSI. In June 2019, the Government of Canada passed Bill C-81, or the Accessible Canada Act, this inducts the first national accessibility legislation that aims to create a barrier-free Canada through "proactive identification, removal, and prevention of barriers to accessibility wherever Canadians interact with areas under federal jurisdiction." This act puts into place compliance and enforcement measures, as well as an accessibility complaints

[3] To distinguish from footnote 1, this includes all adults with visual impairments who responded to the survey

mechanism. Notably, included in the vision of this act, the federal government aims to increase access to employment opportunities and accessible workplaces and accessible digital content and technologies delivered through ICTs (Government of Canada, 2020). At the provincial level, the Accessibility for Ontarians Act (AODA) develops and enforces accessibility standards and has put forth the goal of an accessible Ontario by 2025 (AODA, 2019). The timing of accessibility legislations put into place suggests an opportune moment to address issues of digital accessibility in the employment setting. This need is further reinforced as the Covid-19 pandemic has raised a number of questions about the future of work and whether virtual work environments will continue post pandemic.

## 1.3 Research question and objectives

This MRP seeks to respond to the needs created by the Covid-19 pandemic and study the gap in research on the impact of the transition to working and training virtually over a distance for BPSI. This investigation began with the following research question: How can we better understand and design inclusive virtual and remote work environments that meet the needs of blind and partially sighted individuals?

The purpose of this study was to:

- develop a deeper understanding of the needs, barriers and context of the virtual and remote work ecosystem for BPSI; and
- to develop and co-design ideas for the improvement of the future of virtual work environments.

## 1.4 A preview: Model of shared intentionality in the workplace

This section includes a preview of the results of this MRP, the model to better understand shared intentionality in the virtual and remote work environment.

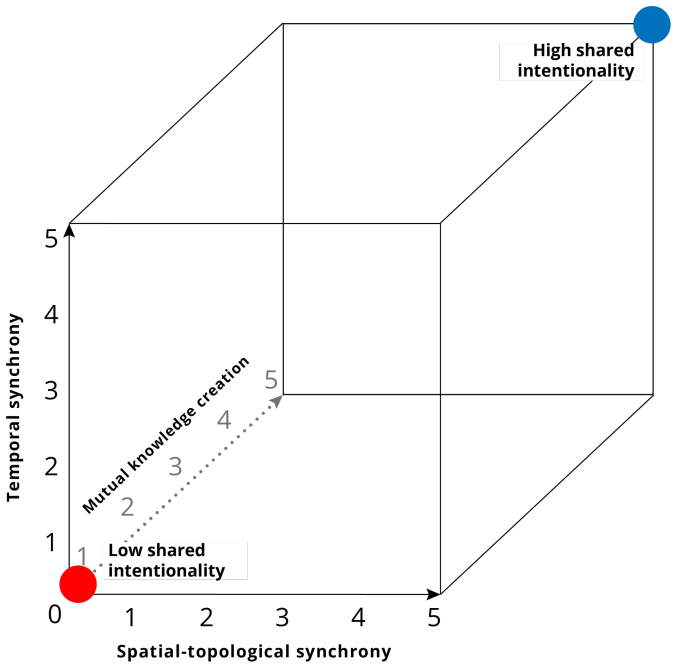


Figure 1: Model of shared intentionality in the workplace

Physical and virtual environments differ in how spatial and topological properties of everyday interactions are conveyed. These are properties of objects, people and the environment that are occupying space and the relations between these. In order to explain how what we perceive can be turned into action, J.J. Gibson's theory of affordances will be introduced. Gibson claims beyond the objects and environments, we are able to perceive 'affordances' which involves turning what is perceived into something that can be acted upon (Gibson, 1979). For example, consider a meeting that is held in the brick-and-mortar workplace, you may enter a room with other people, furniture, a whiteboard and office supplies. These people and objects in the room possess spatial and topological properties that when perceived the individual may apply meaning to or act upon, and this aids in the understanding that a meeting is occurring. Virtual environments, on the other hand, are limited in the spatial and topological properties that are conveyed, thus limiting the transmission of important cues such as gesture, tone, body language, that are used to infer the intentions of others. What can be perceived of the people, objects and environment is restricted to what the interface facilitates, in most cases the video captures what is immediately placed behind the individual. These spatial-topological properties are even further limited for BPSI who may range in their ability to perceive visual information, as well as in

scenarios where the individual chooses not to turn their video on. The temporal nature of the interaction through ICTs is another important factor in how shared intentionality is generated. In this MRP, these interactions will be examined on a scale from synchronous to asynchronous. For example, video conferencing, screen sharing, working on collaborative documents at the same time (e.g. Google Docs) are synchronous interactions. Chat and email may range from synchronous to asynchronous depending on when the interaction occurs. Recorded videos, powerpoints are examples of asynchronous interactions in the workplace. This MRP hypothesizes that synchronous interactions provide greater opportunities for spatial and topological properties to be perceived. Mutual knowledge creation refers to the internal representations that two or more individuals create based on their diverse perspectives and experience, this provides a framework for how people may infer and apply meaning to what they perceive in the world.

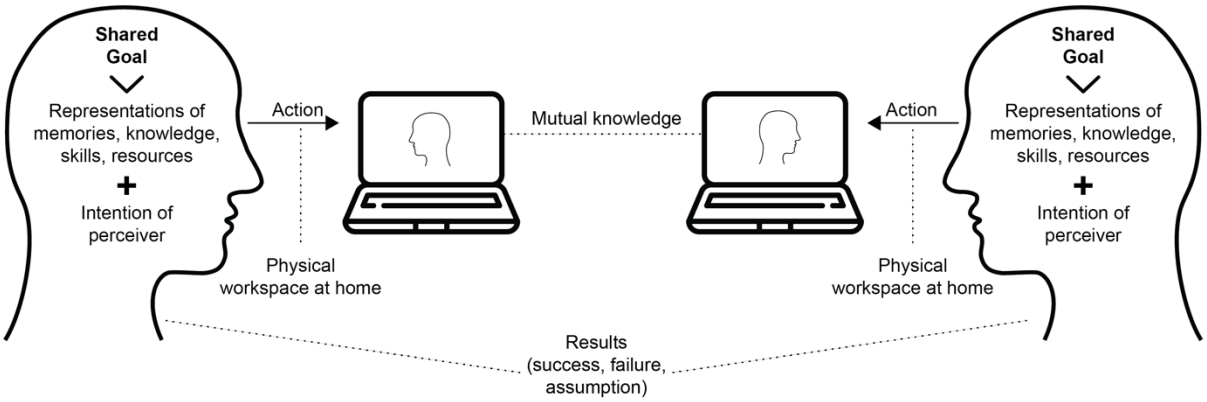


Figure 2: An adapted version of Tomasello et al.'s (2005) shared intentionality.

Built via the findings from this MRP, this model proposes that spatial and topological properties of everyday interactions, the temporal nature of the interaction and mutual knowledge creation are the dimensions by which shared intentionality, the capacity that enables humans to "act together intentionally, in a coordinated and cooperative fashion, and to achieve shared goals," (Schweikard and Schmid, 2020) is developed. Figure 2 demonstrates how shared intentionality is formed in virtual work environments. Each employee's understanding of the shared goal is informed by their internal representations based on previous experiences, the

spatial and topological properties conveyed through ICTs and the mutual knowledge creation. This results in the success or failure of the shared goal. This MRP adds the possible result of assumption, where in the absence of spatial and topological properties or difficulty in mutual knowledge creation, the employee relies on the internal representations to infer the intentions of the other employee, which could lead to assumptions formed.

Shared intentionality requires individuals to infer the intentions of others. In situations where individuals can draw upon knowledge based on experiences with individuals, as resources for inferring the intentions of those individuals, the more effectively there is what I refer to in this MRP as 'synchronization of experience.' In everyday interactions, individuals perceive words, gestures, levels of emotion, body posture, and beyond for synchronization. It is hypothesized that when synchronization of experience is increased, individuals can inform their internal representations of intentions based on memories of actual interactions with those individuals. However, when synchronization of experience is reduced, individuals must rely on memories of other experiences (or even stereotypes or assumptions) as resources for inferring the intentions of others. How effectively ICTs facilitate synchronization of experience depends on how effectively interfaces provide perceptual cues (in a format that diverse individuals have access to) to afford synchronization of experience that can enable effective internal representations required for shared intentionality. For example, it was found that BPSI feel that they have to defend their competence while discussing their assistive technology needs. While this finding was collected by this MRP, this example will be extrapolated to demonstrate this hypothesis. Let's consider that this was a procurement request that was completed through an online form, submitted through email and received by a sighted IT specialist. In this scenario, email was used, an often asynchronous interaction with no spatial or topological properties of everyday interactions conveyed, as well the IT specialist and the BPSI weren't able to engage in a conversation through this online form that could have provided more knowledge, which may impact their ability to fit assistive devices. One interpretation of this scenario is that shared intentionality is very low and in the absence of this results in a greater inclination for the IT specialist to rely on inference to fulfill this request which may explain why the individual felt that they had to defend their competence.

## 1.5 Significance

The implications of this model can be substantial and extend our understanding of a number of key aspects of virtual work environments for BPSI. This section outlines the possible contributions of this model of shared intentionality in the workplace.

This model can be used to better understand the role of ICTs in facilitating information in virtual environments and the impact of this on shared intentionality. The proposed dimensions of shared intentionality could be examined in isolation or together to understand barriers and challenges, as well as develop solutions for digital accessibility. For example, organizations can work towards inclusive virtual working solutions such as taking steps towards accessible meetings. Sharing materials in advance, stating your name prior to speaking on video calls are steps that can be taken to increase the spatial and topological properties and thus synchronization of experience that provides inclusive ways for BPSI to fully engage in the workplace. Furthermore, this model can extend our understanding of digital accessibility, accessibility policies, procedures and processes within the organization that can lead to more inclusive and innovative solutions.

ICTs are critical to how individuals communicate in virtual environments. This model allows technology developers, organizations and IT specialists to gain a deeper understanding of how ICTs facilitate spatial and topological properties in an accessible way. Further, it was found that the diverse perspectives of BPSI provides a necessary perspective in the development of these platforms, this integrates accessible development from the beginning of the process rather than as an auditing measure that may come in at the end of development. This could lead to adaptive ICTs that meet the needs of BPSI. Moreover, emerging technologies such as haptic glove technology and virtual reality are capable of simulating experiences, suggesting further ways through which spatial and topological properties are effectively transmitted. Future research and development for accessible ways to integrate these emerging technologies in the workplace would greatly impact the perceptual cues that are accessed by BPSI through ICTs.

This model provides a deeper understanding of the role of shared intentionality in how people interact with one another in the workplace. In situations where shared intentionality is low, it is interpreted that synchronization of experience is reduced and individuals must rely on memories of other experiences, or in extreme scenarios, stereotypes and assumptions as resources for inferring the intentions of others. This model has presented dimensions of shared intentionality and how these can be modified through virtual working solutions to reduce the likelihood of individuals relying on inference, stereotypes or assumptions and gain the information about the interaction through the available spatial and topological properties that are conveyed through ICTs.

## 1.6 Limitations and scope

The limitations of this study resulted from scoping a project that was feasible to accomplish within the Master's major research project timeline. Limitations included the theoretical scope and scope of the literature drawn upon.

This MRP's proposed model seeks to provide an interpretation of the complex phenomena that have arisen as a result of the transition to virtual work environments, for this reason it enables 'predictive explanations,' in this paper these explanations are outlined in section 4.0. However, given the theoretical scope this model was not tested, identifying the accuracy of these predictive explanations is an identified gap of this MRP and could be the source of future studies. Testing the model's ability to generate accurate predictions would distinguish what is an expected *prediction* or expected *explanation* of shared intentionality in the workplace (Hoffman et al., 2017). It would be beneficial to implement a survey or tool to capture the distinct benchmarks of spatial and topological properties, temporal nature of interactions and mutual knowledge creation.

The scope of the literature drawn for this study was limited to what supported the development of the model, as well as supported the observations from the conducted research activities. This MRP did not entirely draw upon the extensive histories and breadth of work on shared intentionality, science of perception and the philosophy of perception.

## 1.7 Outline of MRP

In the following sections this MRP will be described in two parts. Part I will present the theories, methodology, research activities and findings that led to the development of the model. Part I begins with section 2.0, which introduces the main concepts that provide the foundation on which the model was developed. This will include an outline of shared intentionality and the role of the phenomenon in the workplace. Following an introduction of theories, in section 3.0 an overview of the methodology and research activities, which included semi-structured interviews, observational research and co-design sessions, will be presented. Part II focuses on demonstrating the model through the data collected from this research study. Section 4.0 will involve a discussion of findings, specific case studies of challenges in the virtual work environment will be presented and interpreted using this MRP's model. The impact of virtual working solutions for accessible workplaces for BPSI will also be discussed. Lastly, implications and recommendations for the future of virtual work environments for BPSI will be demonstrated through the model.

# Part I

Better understanding the employment ecosystem and virtual and remote work environments for Blind and Partially Sighted Individuals

# 2.0 Theories and key concepts from the literature

This section outlines the theories, concepts and previous work that informed this MRP and the development of the model. The crux of this section involves the concept of shared intentionality that will be discussed in more depth than presented in section 1.0. In addition, how representations are conveyed through virtual environments, or ICTs, and how this aids in the construction of shared intentionality will also be outlined.

## 2.1 Shared intentionality

Scholars from philosophy, cognitive science and developmental psychology have explored the concept of shared intentionality, which is "the power of minds to be jointly directed at objects, matter of fact, states of affairs, goals, or values" (Schweikard and Schmid, 2020). Although the term shared intentionality was more recently coined in the 20th century, it is the most recent version of an ancient concept that was implied by philosophers such as Aristotle, who referred to this concept as common striving, and Jean-Jacques Rousseau, who referred to this concept as collective will. Many scholars have studied what it means to intend as a group, with different schools of thought that can be distilled to two views. The first is that of *irreducibility*, which is the view that shared intentionality is not the sum of individual intentions (and therefore cannot be reduced to individual intentions). The second is that of *individual ownership*, the view where intentionality is unique to the individual. For example, under the individual ownership view if Individual A intends to go for lunch and Individual B also intends to go for lunch, then Individual A and Individual B intend to go for lunch. Under the irreducibility view, if Individual A intends to go for lunch and Individual B also intends to go for lunch, then Individual A and Individual B collectively intend to go for lunch.

A more recent (and possibly more familiar) conception of shared intentionality in common use today appears in the early social theory of scholars such as Emile Durkheim and Max Weber. Emile Durkheim claimed that social facts, values, cultural norms and social structures "have to be accounted for in terms of a shared consciousness rather than individual attitudes." He believed that shared consciousness "tak[es] over control and bypass[es] individual intentional psychology in the explanation of action" (Durkheim, [1898] 1994 as cited in Schweikard and Schmid, 2020). Max Weber, on the other hand, claimed the opposing view that social facts consist of intentional attitudes of individuals, where social situations "are strategic interdependence between individual decisions" (Schweikard and Schmid, 2020).

Since then, prominent philosophers have distilled these two views to the difference between "I-intentions' ' and "We-intentions," which are the contemporary terms for the previously discussed central problem of shared intentionality. This study uses key aspects from both of these debates, which is that intentions induce behaviours caused by the mental representations that are causing them (Velleman, 1997). Theory of mind plays a key role in shared intentions, which is the ability to attribute mental states to ourselves and others which serves as one of the foundational elements of social interaction (Wellman, H.M., 2002). Returning to the lunch example, it can be argued that shared intentions are developed by Individual A acting on their mental representation of Individual B's mental representation of Individual A's intention to go to lunch with Individual B, and so forth.

Synergistic with this foregoing example, Michael Tomasello's work studies the point at which the ability to share intentions develops in a young child. Tomasello's theory is that understanding mental states begins earlier than what theory of mind claims, which is that this occurs at 4 years old. He claims that it is the capacity for shared intentionality that distinguishes humans from primates. Tomasello et al., states that "participation in [shared intentionality] requires not only especially powerful forms of intention reading and cultural learning, but also a unique motivation to share psychological states with others and unique forms of cognitive representation for doing so" (Tomasello, et al., 2005, p. 675). This ability to understand individuals as intentional agents are foundations for children's ability to "representationally redescribe their understanding of persons using the culturally shared symbols of their language,

and so begin down the road not just of shared intentionality with other individuals but of the shared intentionality that constitutes their culture" (Tomasello and Rakoczy, 2003, p. 143). And so, the ability to understand others as intentional agents and participate in the social institutions of their culture, is thought to "offer predictive power in social interactions" (Jensen, 2016, p. 301).

## 2.2 Shared intentionality in the workplace

Schweikard and Schmid, describe "coordination [as] a basic social phenomenon. It comes into play when there are two or more agents each of which has two or more options which are known to the agents to be interdependent in such a way that it does not matter so much to any individual participant which option is chosen, just as long as all agents converge on one option" (Schweikard and Schmid, 2020). This type of social organization plays a role in the workplace, where there are goals, tasks and deadlines which require one or more employees to converge and coordinate.

De Visch and Laske have built on Tomasello's work on shared intentionality to conceptualize what happens in meetings. In their words, meetings allow for "a mutual understanding of who can or will do what when" (p.49). In understanding who can do what, there is a level of self-monitoring and social monitoring that takes place. They argue that these processes function outside of shared intentionality. And so, they build on Tomasello's work by contributing the notion of an 'internal workplace,' the space in which meeting participants "construct their role identity and its interpretation" (p. 47). This internal workspace, in combination with shared intentionality, may predict how a meeting will unfold, and by extension how teams will work together.

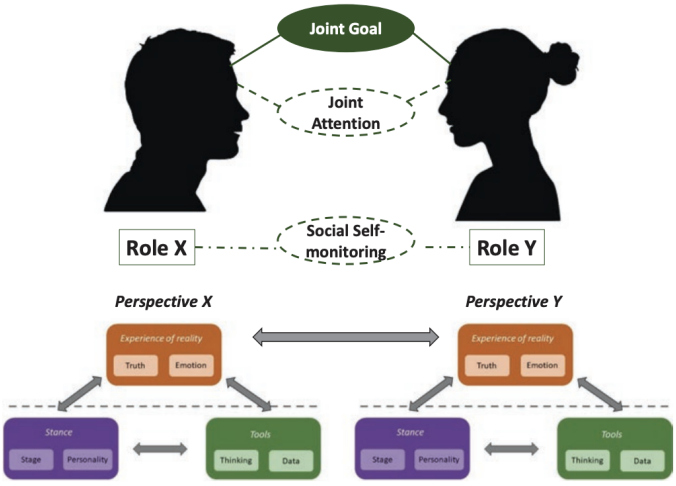


Figure 3: De Visch and Laske's (2020) conception of what happens in meetings, which is two individuals, referred to as Role X and Role Y, developing shared intentionality, in addition to social and self monitoring. From "Practices of Dynamic Collaboration," by De Visch & Laske, 2020, p. 50. Copyright 2020 by Springer Nature Switzerland AG.

In Figure 3, De Visch and Laske illustrate the dynamics of collaboration in meetings. It can be seen that what bridges two people is aligning on a focal point or 'joint goal,' which is the foundation of shared intentionality. However, they propose that each individual brings an 'internal workplace' to the team, which are the internal representations of their roles and contribution. De Visch and Laske identify that two people have distinct social self-monitoring, as such "holds a specific perspective on the social world around them" (De Visch & Laske, 2020, p. 50).

Other previous work of note were those exploring how shared intentionality plays a role in group dynamics in professional settings. The impact of shared intentionality in aligning with an organization's strategy was explored by Ungureanu et al., where they found how levels of shared strategic intentionality about the broader organization's strategy was important in how well-being initiatives, or programs that enhance employee health and well-being, were perceived by employees (Ungureanu et al., 2019). In symphony orchestras, the role of empathy and shared intentionality were found to impact cooperative governance, where "empathic experiences,

shared intention, entrepreneurship and innovation are key underpinnings to social enterprise formation" (Seddon et al., 2014, p.13). In the healthcare setting, Bleakley et al. (2009), explored the shift from multiprofessionalism, or the individual silo mentality, to interprofessionalism, or a more collective mentality, in building a climate of teamwork in operating rooms. They found that this shift resulted in "collaborative intentionality capital" which in turn led to increased patient care and safety as a result of the interprofessionalism that was fostered by the team (Bleakley et al., 2009).

## 2.3 Representations in virtual environments

The physical distancing that resulted from the Covid-19 pandemic meant that the majority of work-related interactions for constructing shared intentionality were conducted through ICT-based virtual work environments. For this reason, this MRP introduces a technical way to talk about properties of representations of ICTs to consider the role that different types of external representations perform in the construction of shared intentionality.

Virtual work environments in the form of ICTs are composed of external representations that can be perceived through our senses. Examples of external representations include the elements of an interface display for a videoconferencing system that runs on a personal computer, which, on the computer screen, is composed of rows of rectangular buttons labelled with text and icons. Through the computer's speaker system, beeps, swooshing sounds, alarms, and spoken language are also external representations, as are the moving images of a video stream during a video conference call.

When BPSI make use of ICT-based virtual work environments, they rely on assistive devices, such as screen reader technology to interact in a manner that does not rely on the ability to visually perceive interface elements such as buttons, icons, and video streams. Developers and professional accessibility specialists aim to make software products (such as ICT-based virtual work environments) accessible to screen reader technology by tagging interface elements with screen readable tags, labels, and text descriptions. However, the types of communication afforded by text, text-to-speech, and spoken language differ from the types of communication afforded by pictures, diagrams, and moving pictures. In order to describe differences of these

perceived *external* representations (as opposed to *internal* representations of the mind, recruited to describe shared intentionality in the foregoing sections), Larkin and Simon's distinction between diagrammatic and sentential representations, will be introduced next to address this.

Larkin and Simon (1987) describe how "the fundamental difference between our diagrammatic and sentential representations is that the diagrammatic representation preserves explicitly the information about the topological and geometric relations among the components of the problem, while the sentential representation does not. A sentential representation may...preserve other kinds of relations, for example, temporal or logical sequence. An outline may reflect hierarchical relations" (Larkin and Simon, 1987, p. 66). In everyday interactions in the virtual work environment, you may experience both diagrammatic and sentential representations. For example, an email you receive is a sentential representation and streaming video during a video conference is a diagrammatic representation. However, individuals with disabilities, and more specifically BPSI, vary in their abilities to access diagrammatic representations that are presented visually. For example, a video stream of the clutter on a desk is diagrammatic under this definition because it preserves explicitly the information about the spatial, topological and geometric relations of the occluded surfaces and edges of the objects on the desk. A BPSI who relies on screen-reader technology has access to text-based tags and labels that describe interface elements, the text of a chat window, and the spoken language of the video conference (if they are not deaf or hard of hearing). However, they will not be able to perceive the diagrammatic (spatial, topological, and geometric) properties of the video stream. If another participant in the meeting verbally describes the objects displayed via the video stream, or writes a description that could be accessed via the chat window or email, they are providing an interpretation, using sentential representations, that may convey a *description* of the visually perceived relations, such as the spatial arrangements of the objects, how they fall sequentially from left to right for example.

However, what is afforded by diagrammatic relative to sentential representations, and how can these different affordances play a role by fostering or impeding the construction of shared intentionality via ICT virtual work environments? Coppin, Carnevale, and Li (2016) extended Larkin and Simon's conceptualization of diagrammatic and sentential representations

by drawing upon a perceptual-cognitive model for distinguishing pictures, diagrams, and text-sentences (Coppin, 2014), to demonstrate how spatial-topological properties of visual diagrams become ambiguous when translated to text-sentences (as required by current accessibility practices, such as the WCAG, as noted above) and that the spatial-topological properties of visual diagrams can be preserved (or more effectively replicated) through a broader palette of (non-linguistic) auditorily perceived spatial-topological cues, such as rising and falling tones, spatial (binaural) audio, timbre and beyond.

For example, suppose there is a picture (a diagrammatic representation) depicting 'three peaks of varying heights,' and this description is what is provided via an ICT to a BPSI learner through sentential representations (speech or text). Ambiguity is introduced because there is an infinite range of spatial, topological, or geometric structures (depicted mountain shapes) that could be taken to fall under this sentential description. This is how the sentential (text or speech) description is more ambiguous regarding the author's intended spatial-topological structure relative to the diagram (depiction of mountains). Non-visual (sonic) diagrams can make use of non-visual sensory modalities. For example, if I visually perceive a large truck passing from my left to my right, a sonic version could be the sound of a large truck passing from my left to my right. This can be used for an ICT-based virtual environment, where video streams are positioned diagrammatically within a grid of spatial relations on the screen. The auditory version of this diagram could be for the speakers to be presented to the listener via directional audio, akin to how participants sitting around a meeting table would be heard from multiple directions.

Without non-visual diagrammatic properties in ICTs, spatial-topological ambiguity can impede the construction of shared intentionality. For example, let's consider the experience of a blind and partially sighted employee in a meeting where another employee is using the screen share function to demonstrate a chart to the team. Charts contain spatial relations, or diagrammatic representations, between plotted points that are critical to infer value and meaning (Coppin et al., 2016). In this example, there may be ambiguity, or a limit, to what sentential representations, language, can convey. In this example, a diagrammatic representation is more precise about the spatial and topological properties of the plot points within the chart. However, sentential representations, or language, are more precise about abstract conceptual categories, for

example if speakers in the meeting identify themselves prior to speaking, this sentential representation of this conceptual category, in this case the name of the individual, at the moment they start speaking, provides more information than a description of the individual (e.g. posture, body language, etc.). The impact of this ambiguity that results from diagrammatic representations converted to sentential representations and its impact on the construction of shared intentionality will be further demonstrated in section 4.0 via the findings of this MRP.

This MRP provides a model for better understanding this spatial-topological ambiguity in ICT-based virtual work environments for BPSI, for whom spatial and topological synchrony, or diagrammatic representations, are more difficult to perceive and rely on the conceptual specificity of language, or sentential representations. This MRP also suggests recommendations for how to address this through the synchrony of spatial-topological, temporal and mutual knowledge creation in order to foster shared intentionality.

# 3.0 Methodology

The previous section outlined the theories and concepts that lay the foundation for the model developed in this MRP. This section will now present the research methods through which the previously identified concepts were processed and synthesized to make model development possible.

## 3.1 Study design

This MRP was conducted using longitudinal participatory design. Participatory design is an iterative approach involving exploration, design discovery, prototyping and assessment that allows "[participants] and researchers to critically examine the impacts of redesigns in progress" (Spinuzzi, 2005). According to Spinuzzi, "tacit knowledge and invisible practices are by nature difficult to tease out," however this methodology aims to draw these out while "preserving the existing web of tacit knowledge, [and] workflow" (Spinuzzi, 2005). The methodology was particularly effective for this MRP which focused on deriving observations from an evolving and dynamic situation that was created by the Covid-19 pandemic. Each stage of the research process was designed based on previous stages and the methodology was fluid and iterative as this study responded to the needs of the virtual work environment of BPSI. Through qualitative research methods, this MRP focused on developing a deeper understanding of the needs, barriers and content of the virtual and remote work ecosystem for BPSI. The study was reviewed and approved by the OCAD University Research Ethics Board, REB reference number #2020-48.

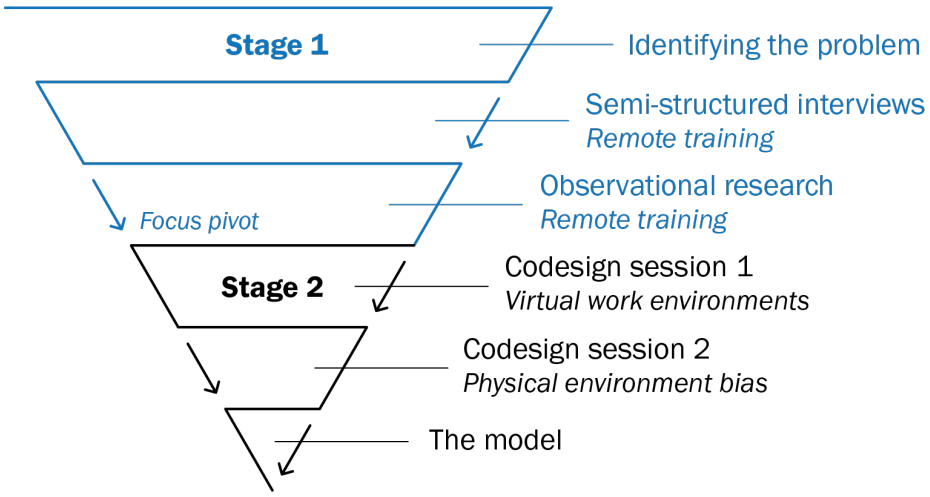


Figure 4: Major research project methodology.

This study experienced a focus pivot between stage 1 and 2 of the research plan (Figure 4). The initial focus of this study was on accessible assistive technology training for the employment setting, however as the proposed research plan unfolded it was difficult to tease apart the impact of the Covid-19 pandemic in the data collected. The research was pivoted for two main reasons. First, there was close alignment of stage 1 of this research study, which focused on assistive technology training, and virtual work environments may be attributed to the fact that both rapidly transitioned to ICTs to continue their programming and working. Many of the findings related to assistive technology training, such as exercising flexibility and adaptability; empathy as an approach; virtual working solutions (e.g. sending materials in advance), paralleled what was shared about virtual work environments. Second, a research opportunity arose at CNIB, the Accessibility Standards Canada (ASC) Grant, "Building an evidence-based universal design framework for employment standards in Canada" led by this student investigator's advisor, Dr. Mahadeo Sukhai. This project focuses on developing inclusive employment standards and educational resources for the workplace setting that focuses on sensory and visual processing disabilities. Dr. Sukhai and his research team held a symposium as part of this grant that revealed a number of overlapping themes. In summary, the findings from stage 1 of this research study and from the ASC grant, intersected around challenges faced as a result of how ICTs are facilitating training and working over a distance for BPSI.

The multi-stage research plan involved (Figure 4):

1. Stage 1: Initial exploration of work and discovery processes conducted through:
    a. 10 semi-structured interviews
    b. Observational research of 2 assistive technology training sessions.
    c. The purpose of this stage was to develop a deeper understanding of assistive technology, assistive technology needs and barriers to training as it relates to employment.
2. Stage 2: Co-design sessions and model development. This stage applied findings from stage 1 of this study and delved deeper on the topics from the semi-structured interviews, observational research and CNIB ASC grant symposium through co-design sessions. In addition, a model verification session was conducted with a co-design session participant to ensure relevance which allowed feedback to iterate the model. The purpose of this stage was to develop a better understanding of virtual and remote work environments for BPSI and synthesize and model the research findings.

## 3.2 Semi-structured interviews

Stage 1 began with semi-structured interviews, the objectives of this activity were to develop an understanding of the current landscape of employment, Assistive Technology (AT) and virtual trainings, as well as barriers to AT and AT training.

Participants were recruited from the CNIB "Come to Work" program talent pool and clients of Vision Loss Rehabilitation Canada (VLRC). Ten interviews were conducted with 4 CNIB clients and 6 CNIB staff. CNIB clients had previously received services related to life skills training, employment counselling and technology training from the VLRC Life Skills program and the "Come to Work" Program at CNIB. CNIB staff included independent life skills training specialists, technology leads and employment specialists. Interviews ranged from one hour to one hour and thirty minutes. See Appendix A for Interview guide. Data was collected through note-taking and video recordings. Audio and video recordings were captured using Microsoft Teams and Zoom, two widely used communication platforms at CNIB.

The main themes that arose from these interviews were barriers to assistive technology (AT) as a result of cost and knowledge; AT was crucial for employment purposes; workarounds for AT trainings make them more personalized for individuals; flexibility and adaptability in approach to AT trainings as a result of the Covid-19 pandemic; tactile skills are difficult to teach through virtual platforms; there is a lack of training standards and guidelines for AT trainings; empathy as an approach; stigma faced in the employment setting; and one size doesn't fit all for AT trainings.

## 3.3 Observational research

The main findings from the semi-structured interviews provided a perspective from which the observational research was conducted. CNIB shifted in-person "Technology Workshops" and other trainings on AT online in response to the Covid-19 pandemic, these workshops are offered to clients using Zoom. The objectives of this activity were to observe the context in which training is delivered, observe some of the identified barriers from the semi-structured interviews, as well to observe the way that the sessions are delivered through ICTs. Digital ethnographic strategies were applied, so that overt participation by this student investigator may allow for "emerging themes and interpretations to be discussed with participants and for hunches and predictions to be tested out" (Hine, 2015). Two sessions were observed, this included: one 1:1 training session with a CNIB client and technology lead; and another group session delivered by a CNIB technology lead and employment specialist from the "Come to Work" program. The data was collected through note taking.

The main themes that arose from the observations included: trainers exercised flexibility in content delivery and methods; trainers adapted the lesson and facilitated through a digital medium that participants were comfortable with; participation was adapted for virtual platforms and engagement was bolstered through the use of polls, chat and calls.

## 3.4 Co-design sessions

The co-design sessions began with an application of key insights from the semi-structured interviews and observational research. Additionally, the previously discussed pivot in research focus informed the co-design sessions. In planning the co-design sessions, there was a paucity of literature found related to accessible research methods conducted over a distance. Moreover, the challenges faced with accessible virtual research methods with BPSI paralleled the results of this study, there were challenges related to how effectively communicating through ICTs transmitted spatial and topological perceptual cues affected shared intentionality, this will be explained in further detail in section 4.1.1.2. Two co-design sessions were conducted that involved a process of research and development where participants were guided and empowered to generate and explore new ideas that were informed by their knowledge and lived experience (Hagen et al., 2012). The participatory design methodology encouraged the inclusion of the same participants, with diverse views over time, this yielded a deeper understanding of the perspectives of BPSI currently immersed in virtual work environments.

### 3.4.1 Session 1

The first session focused on inclusive virtual and remote work environments for BPSI. There were seven participants in attendance who were CNIB research staff and experts from the vision loss community. This session was one hour and thirty minutes and was conducted through Microsoft Teams. See Appendix B for Codesign session guiding document. The data was collected through note-taking and recording the session. This session focused on developing a deeper understanding of the needs, barriers and context of the remote work ecosystem for BPSI, as well to highlight pain points of the ecosystem and discuss recommendations and ideas for improvement for the future of virtual and remote work for BPSI. In this session, there were two activities conducted, the Rose, Bud, Thorn and Insights, Questions, Ideas activities. The Rose, Bud, Thorn activity involves identifying aspects of the work environment that are positive, negative and has potential. The Insights, Questions, Ideas activity was a way to collaboratively group the data captured thus far into categories, thus allowing for themes to emerge. Through these activities, an understanding of what's working and not working with virtual and remote

work for BPSI was developed. The following themes emerged from the discussion: empathy as a general approach and embedded in training and education; assumptions about BPSI in the workplace; managerial practices, assumptions and training and education; accessible technology development; physical environment bias (further discussed in section 4.2.3.1); equity issues the pandemic uncovered; and system redesign.

### 3.4.2 Session 2

The second session narrowed in on the findings from co-design session 1, the focus of this session was the emerging theme 'physical environment bias.' This bias refers to the preconception that working in-person and in the same space is required to complete work. We further explored how many accessibility and work practices are designed to function in the physical environment as opposed to the virtual. There were six of the seven participants from session 1 present who were CNIB research staff and experts from the vision loss community. This session was one hour and thirty minutes and was conducted through Microsoft Teams. The data was collected through note-taking and recording the session. The purpose of this session was to develop a deeper understanding of the aspects of the physical environment bias that are both lost and gained when translated into the virtual environment, highlight pain points of what doesn't work in the virtual environment and co-design ideas for the future of virtual and remote work. The following themes emerged from the discussion: accessibility guidelines and policy are focused on the physical environment; how do virtual environments affect how humans interact during work; employer/employee decision making, productivity and responsibilities in the virtual environment and; virtual working solutions and the future of work post pandemic.

## 3.5 Summary of Part 1

Thus far, the theories, methods and research activities that underlie this MRP's model were presented. An overview of shared intentionality and how this uniquely human capacity plays a role in the workplace was discussed. As well, section 3.0 presented a map of this research study's activities and the main themes uncovered. The next part will begin by explaining the

model through two case studies in the workplace. This will then be followed by the findings from this research study that will be demonstrated via the proposed model.

# Part 2

A model of shared intentionality in virtual work environments

## 4.0 The model and discussion of findings

This section presents an interpretation of aggregated findings from the semi-structured interviews, observational research and co-design sessions using the proposed model for understanding shared intentionality in virtual work environments.

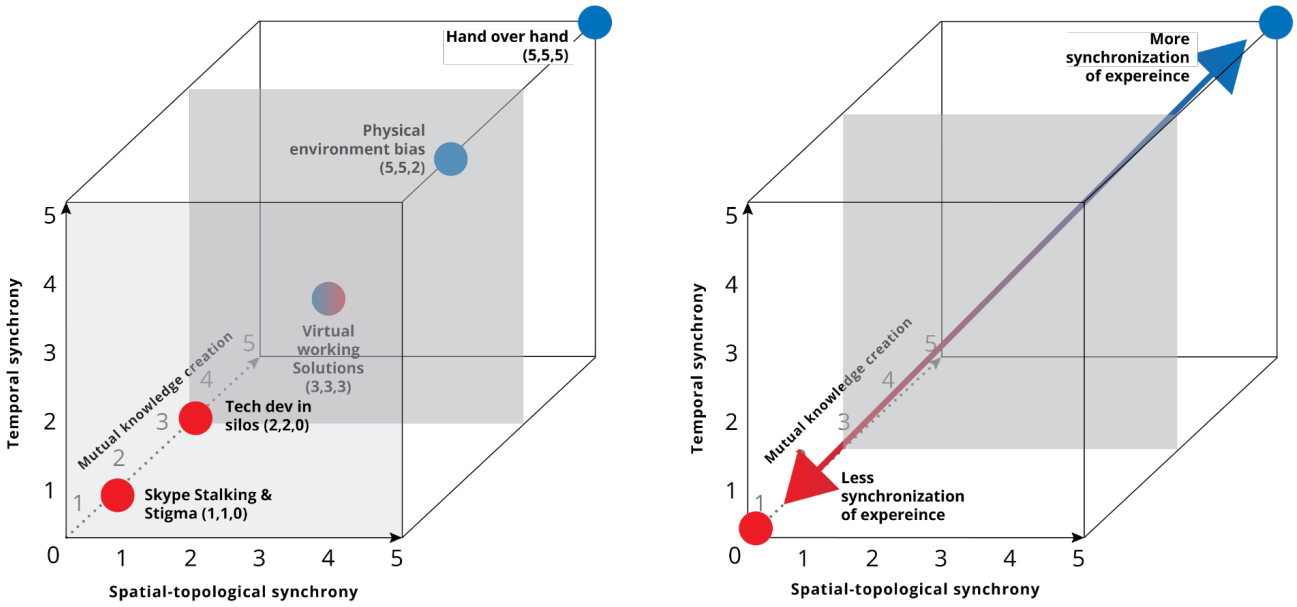


Figure 5: Findings from this MRP explained via the model (left) and levels of synchronization of experience (right).

Figure 5 (left) maps the analysis and explanations of the findings in terms of three dimensions of a Cartesian coordinate system. These are the degree to which:

1. ICTs represent spatial and topological properties (Figure 5 [left], x-axis), herein referred to as **spatial-topological synchrony;**
2. interactions via ICTs are synchronous or asynchronous (Figure 5 [left], y-axis), herein referred to as **temporal synchrony** and;

3. there is the ability for a diversity of perspectives to come together forming new agreed upon mutual knowledge, herein referred to as **mutual knowledge creation,** eases synchronization of experience for the construction of shared intentionality (Figure 5 [left], z-axis).

In the Figure 5 (right) model, the closer a case study falls to 0,0,0 the more it demonstrates conditions that are less conducive for synchronization of experience required for the construction of shared intentionality whereas the closer it falls to 5,5,5 the more the case study demonstrates conditions that are conducive for synchronization of experience required for the construction of shared intentionality. The sections that follow will demonstrate case studies from this study where the synchronization of experience constructed or did not construct shared intentionality. It is from these case studies that this MRP's proposed model was developed.

## 4.1 Case study 1: Skype Stalking

An assumption reported by participants of this study is a practice called "Skype Stalking" (Figure 5 [left], Skype Stalking). Skype Stalking falls closer to 0,0,0 in Figure 5, serving as an extreme example of a scenario where the synchronization of experience, and therefore shared intentionality, is difficult to foster. In what follows, this practice, described in terms of the three dimensions of the model is discussed.

Skype Stalking was when managers would infer whether employees were "at work" based on whether or not an information display of an ICT (such as in Skype) displayed the employee's status as "online." The inference that employees were online was then being used to further infer whether they were working on their assigned tasks. Consider this in terms of the Figure 5 model: Remote work means that the manager was unable to directly observe whether or not the employee was "at work," how hard they were working, and what task they were working on through perceptual cues of employees working in a brick-and-mortar environment, that more freely affords perception of spatial-topological properties of objects and people in the room, which contributes to the synchronization of experience required for shared intentionality. Skype Stalking appears to be an attempt to compensate for the paucity of spatial-topological cues by

relying on internal representations based on memories of previous interactions. In previous interactions, an online status indicator may have signaled to a manager that an employee was online, and therefore hard at work. In Figure 5 (left), this lack of access to spatial and topological perceptual cues via an ICT places this example at Level 1 of the 5-point scale of the x-axis (low spatial-topological synchrony). Additionally, although Skype Stalking relies on an ICT display that claims to indicate the employee's status synchronously, the indicator conveys no information about whether the employee is actually engaged in work-related tasks, thus placing this example at Level 1 of the 5-point scale on the y-axis (low temporal synchrony). Now consider the types of misunderstandings that could transpire through Skype Stalking without some type of mutual knowledge creation between managers and employees about the working styles of employees relative to expectations of managers and how this may or may not be accurately displayed through Skype stalking. For example, a situation where an employee is more productive during non-standard hours (e.g. 9 am to 5 pm). The employee in this case study reported that managers may not possess the knowledge of disability, or had previous conversations with BPSI at the organization, and is therefore relying on assumptions of how work should be done, thus placing this example at Level 0 on the z-axis of Figure 5 (low mutual knowledge creation). Together, the three dimensions of the model place this example in the far lower left, at 0,0,0 (less overall synchronization of experience and therefore less conducive for the construction of shared intentionality [Figure 5, right]). Consider how the lack of shared intentionality could impact the working relationship in the long-term. This employee could feel surveilled overtime. This could impact trust amongst team members, which in turn could affect how the team cooperatively works together to meet deadlines and complete projects. Furthermore, there was evidence of stigma related to accommodations to work from home due to disability prior to the pandemic, as well blind and partially sighted employees may feel they have to defend their competence when requesting assistive devices for work. The Ontario Human Rights Commission outlines that "stigma, negative attitudes and stereotyping can lead to inaccurate assessments of people's personal characteristics" (OHRC, 2021). This study argues that in the absence of perceivable personal characteristics, or spatial-topological cues there is greater reliance on internal representations from previous experiences, causing inaccurate assessments about people (Figure 5 [left], Stigma). In this study, it can be interpreted that stigma

and discrimination is on the extreme end of relying memories of other experiences to infer the intentions of others, as a result of reduced synchronization.

The next section considers how the model's deconstruction of the case study to the three dimensions of the model offers a pathway for providing recommendations to remedy the problem of forming assumptions in settings with low synchronization of experience.

### 4.1.1 Recommendations: Alternatives to Skype Stalking

Skype Stalking and stigma falls at 0,0,0 in the Figure 5 model, a situation that is not conducive for the synchronization of experience that serves as the basis for shared intentionality. In this section, recommendations to improve the construction of shared intentionality through the synchronization of experiences by increasing spatial-topological synchrony, temporal synchrony, and mutual knowledge creation are considered.

#### 4.1.1.1 Mutual knowledge creations eases synchronization of experience

The participant who described their experiences with Skype Stalking reported how an assumption is formed based on how managers believe the job should be completed. Skype Stalking appears to make two assumptions, first that an ICT dashboard that indicates an employee is online signifies that the employee is truly online, and second that an employee being online signifies that the employee is engaged in their assigned task. However, as noted in 4.1, these assumptions might fail in many cases. Consider several possibilities that could include misunderstandings: An employee might not be aware that the manager has these expectations, this study found that employees sought clarity around expectations and responsibilities. A diversity of perspectives and backgrounds, where different practices and expectations were embedded in previous work could result in ambiguity of representations of how the workplace should function, thus increasing the likelihood for ambiguity and resulting in assumptions about what the employee is doing. Every employee possesses their own interpretation, or internal workplace, which includes their self-perceived understanding of the role and responsibilities (De Visch & Laske, 2020). This internal workplace constrained by what is offered by the virtual

environment, or reduced synchronization of experience could result in ambiguity of representations. Furthermore, participants shared that sighted managers are not deemed fit to determine appropriateness of assistive technology as they do not possess the lived experience of disability that would inform this decision. In this example, the sighted manager and the blind and partially sighted employee may not have an opportunity to discuss and learn from one another about assistive technologies, in order to develop the mutual knowledge creation required for shared intentionality. Another source of misunderstanding could be differences in working styles. An employee might intentionally log out of Skype and other social media accounts to reduce distractions while engaged in their assigned tasks, thus possibly causing the manager to assume that this individual is not working. Lastly, a source of misunderstanding could arise from lack of awareness of contextual factors, a participant shared a scenario where an employee wasn't available in the same manner in virtual work environments at the beginning of the Covid-19 pandemic, as such it was assumed this individual wasn't working. This was further perpetuated by the fact that they kept their video off during video conferences. It was later discovered that this individual had caregiving responsibilities and these did not impact their competency or long-term performance. In this example, the manager lacked the spatial and topological cues that video conferences can provide to gain more contextual information about the employee and how these may affect their performance.

These misunderstandings could be alleviated over time as the employee and manager explicitly describe their expectations, but then also iteratively explore practices that, over time, cause them to engage in mutual knowledge creation, a precursor to shared intentionality. These conversations and perspective sharing generates mutually agreed upon knowledge, or representations, through training and education. In this study, participants shared the need for training and education related to accessibility in the context of organizational onboarding of new employees, as well as embedded in ongoing management skill building. This is an opportunity for employees and employers to come together to engage in mutual knowledge creation and skill development, through shared and agreed upon representations that they can call upon at a later date to counter assumption building and make sense of interactions in the workplace.

#### 4.1.1.2 How ICTs facilitate spatial-topological synchrony

As noted, a brick-and-mortar workspace affords the ability for a manager to gain implicit cues (in the form of spatial and topological properties) that can signify how the employee is at work, the type of task the employee is engaged in, and their level of focused intensity on those tasks. The simplest of these is whether the employee is present at their desk. Most office workers are aware of how an empty desk can foster the impression that an employee is late for work, is taking too many breaks, etc. If an employee is at work, and in an open area, their posture, the orientation of their gaze on computer screens or other work materials, also serve as implicit cues that inform a manager's impressions of an employee's level of engagement.

When employees are assigned to offices, other spatial and topological cues have become conventions that signify the activities of the employee inside. For example, a door slightly ajar often signifies that the employee is at work, but probably should not be disturbed because they are in a meeting, on phone call, or engaged in a focused task. An open door, as suggested by the phrase "my door is always open," can signify how the employee is at work, is engaged in work-related tasks, but is open to productive interruptions, questions, and relevant work-related conversations from colleagues as they arise. This "door open" practice was a common way to foster synchronization of experience prior to Covid-19 induced physical distancing. For example, participants shared that even with a portable laptop computer that could afford productive work from numerous locations other than an assigned office, it was still common (and expected) for employees to go to their offices during core hours to afford the types of synchronization that are possible due to an employee being present, at work, in their office, but with their door open. As a result of this phenomenon, participants discussed the existence of a physical environment bias, which is a bias towards decision making in the brick-and-mortar environment, this will be further elaborated in section 4.2.3.1.

In this study there were challenges found related to the lack of afforded diagrammatic properties of working over a distance via ICTs. It was found that during a video conference, an individual may feel inclined to sit still as shifting in their seat or getting up and walking around would limit the perceivable spatial and topological properties an individual on the other side of the interaction has access to. Overlapping audio was also a challenge with these platforms, a

participant shared that they felt they were uncertain about being intrusive and interjecting during a meeting. These changes in how we communicate results from the lack of spatial and topological properties, which in these examples results in interruptions or uneven participation. BPSI range in the amount of visual information they have access to and it was found that some participants found it more challenging to interject, while others felt that interjecting came naturally without the visual cues.

How can spatial-topological synchrony afforded by diagrammatic properties in a brick-and-mortar work environment be translated to working over a distance via ICTs? For example, a routine meeting between the manager and employee, each week, at a set time, and that takes place regardless of weekly progress is one potentially effective strategy. In addition, during virtual meetings, if speakers announce their name prior to speaking it was found to be a helpful way to provide some spatial-topological properties in the absence of what is afforded by the brick-and-mortar environment, however a participant did find that it isn't enough to build a "mental map" of the room. Consider how directional sound, which allows customizing the direction from which the source of sound occurs and is conveyed through ICT speakers, preserves the diagrammatic properties of the meeting and could aid in spatial-topological synchrony.

In the next section, this MRP reports on examples of research methods that were used in this study to afford spatial-topological synchrony by exploring ways to preserve diagrammatic properties of interactions in person. In preparation for the co-design session in this study, it was found that many design activities and mapping tools relied on visual perception and in-person interaction. However, the space in which these sessions were conducted was a remote non-visual setting. The challenges to conducting research given these considerations paralleled the challenges faced by BPSI working in ICT-based work environments. The methods and tools presented in the following sections, afforded varying levels of spatial and topological perceptual cues and synchronous engagement which contributed to the development of synchronization of experience.

The Microsoft Teams interface was found to impact collaborative activities and made turn taking during conversations more challenging. There was little access to spatial and topological perceptual cues for some participants, many did not turn their videos on. As well, the format of Microsoft Teams does not allow for sidebar conversations without initiating a breakout room, which may have been challenging for novice Microsoft Teams users. In the co-design sessions, the platform afforded some spatial and topological properties based on participants comfortability with turning on their video and engaging in conversation.

Collaborative excel sheets in OneDrive were tested as a way to increase shared intentionality in the co-design sessions. These excel sheets provided sentential representations of the discussion that BPSI had access to in real time. It was shared that while both Google Docs and OneDrive were accessible it was easier to use OneDrive as there was only one toolbar to navigate with their screen reader, which could be the result of many sentential representations that were initially developed diagrammatically. This being said, a few blind and partially sighted participants found it challenging to navigate both the excel sheet and Microsoft Teams with their screen reader. However, some participants found the collaborative excel sheet an engaging way to participate in the session and findings represented in a sentential way were helpful for recall. Troubleshooting how interfaces have represented content demonstrates how important ICTs are in how diagrammatic properties of interactions are conveyed in virtual environments.

The affordances of the chat function in Microsoft Teams was used in place of sticky notes for the Rose, Bud, Thorn and Insights, Questions, Ideas activities in co-design session 1. This was a synchronous way to type in ideas as they came up, this was a shared representation that all participants had access to, similar to what in-person sticky notes may afford for individuals with access to visual perception. While the participants uploaded their ideas, they were sorted in a collaborative excel sheet, this was intended to preserve the synchronous nature of the original design activity. At the end of both design activities, the ideas were thematically arranged to find emerging insights and ideas to further discuss. In-person this may involve grouping sticky notes or grouping these on chart paper, this is not accessible or an option remotely. Thematic sorting of ideas using the collaborative excel sheet was found to be more challenging. The generative nature of live sorting sticky notes to discover emerging themes was

lost in the virtual translation to a collaborative excel sheet, filter options and moving data in the cells around was challenging to navigate while still talking to one another. Thematic coding over a distance is an example of how diagrammatic properties are lost when translated to sentential representations. It was challenging to arrange the cells in the collaborative excel document in a way that demonstrated relations. Further research on other non-visual design tools would be beneficial for thematic coding, which is an often used activity to sort ideas for emerging themes.

#### 4.1.1.3 Synchronous vs. asynchronous interactions through ICTs

A particularly challenging aspect of virtual communication was pre-meeting chit chat or what the participants identified as 'water cooler effect.' These are the types of synchronizations that are possible that are unplanned. These can transpire at the water cooler, at the office coffee pot (back when this was a common practice), while passing colleagues in a hallway or stairwell. In the virtual workspace impacts on the social environment, like the water cooler effect, were found which resulted from reduced synchronous interactions. This included questions regarding accountability and anonymity in the virtual environment, the remote work transition allowed employers and employees to choose the amount of spatial-topological properties they shared (e.g. muting microphone, turning video off). Participants questioned the impact of this on sharing, distance and maintaining relationships with coworkers, as well as whether new social protocols and reduced formalities may take over should this virtual work environment continue beyond the pandemic. A workaround currently being employed by a participant of this study is to spontaneously call other employees in order to address work matters. While phone calls do not possess all of the affordances of an in-person interaction, this is one way to convey spatial-topological properties in order to connect with other employees.

## 4.2 Case study 2: Hand over hand

The 'hand-over-hand' method, (Figure 5, Hand over Hand) is where an instructor places their hands directly on a blind and partially sighted client's hands to show them how to perform certain actions. This method is often used when teaching life skills, such as cooking, or gestures

on a smartphone. Consider how hand-over-hand is a means to convey the instructor's intended spatial, topological, and geometric properties of actions (such as for cooking) and is therefore a haptic form of diagrammatic communication under Coppin et al.'s adaptation of Larkin and Simon's definition. Also, building on Coppin et al.'s (2016) response to Larkin and Simon, consider how a hand-over-hand demonstration overcomes the spatial-topological ambiguity of a sentential form of communication, such as a verbal or written description of the action required for the cooking activity, by physically positioning the learner's hands into the intended configuration required for the physical activity that is being taught. Hand over hand falls at 5,5,5 in Figure 5, serving as an example of a scenario where synchronization of experience has occurred on all dimensions. This situation, described in terms of the three dimensions of the model is composed, follows:

1. **Spatial-topological synchrony:** BPSI make use of multiple sensory modalities outside of vision to perceive spatial and topological configurations of brick-and-mortar workspaces. The instructor's hand-over-hand demonstration takes this further, placing this example at Level 5 of the 5-point scale of the x-axis (high level of spatial-topological synchrony).
2. **Temporal synchrony:** The hand-over-hand method, in addition to being conducted in-person, is conducted synchronously, placing it at Level 5 of the 5-point scale of the y-axis.
3. **Mutual knowledge creation:** Participants found instructors with sight loss more relatable as they possess the internal representations of learning these activities for the first time and from these representations mutual knowledge was developed between them, placing mutual knowledge creation at Level 5 of the 5-point scale of the z-axis.
4. **Synthesis**: Combining the dimensions, this example is placed in the far upper right, at 5,5,5 (high Synchronization of Experience).

### 4.2.1 Overcoming the spatial-topological ambiguity of sentences

Consider the difficulties instructors face when translating the 'hand-over-hand' method to ICT virtual environments. Transmitting these actions requires the instructor to heavily rely on how effectively ICTs are able to convey spatial and topological properties via diagrammatic

representations which, in most ICTs, is via video streaming. However, if the learner is blind and partially sighted, access to these diagrammatic perceptual cues via video will be limited.

In many cases, this study found that instructors and staff compensated by relying on language to describe spatial and topological relations that otherwise would have been conveyed via diagrammatic representations to sighted participants. However, it was found that gestures and actions were more challenging to describe and participants lacked a consistent language to translate these typically in-person recreational activities to virtual environments. In this example, instructors were compensating for the lack of gestures and actions, or diagrammatic representations, conveyed and replacing these with descriptive language, or sentential representations. Ambiguity about concrete structures can result from this translation of diagrammatic to sentential representations, this ambiguity is created by the loss of spatial and topological properties in this translation. The section below outlines strategies to reduce this ambiguity.

### 4.2.2 Recommendations: Diagrammatic properties conveyed through ICTs

#### 4.2.2.1 Using emerging technologies that effectively convey spatial and topological properties of everyday actions

Emerging technologies such as haptic glove technology are capable of simulating experiences, suggesting further ways through which spatial and topological properties are effectively transmitted. In other words, a haptic glove is able to transmit interactions like ‘hand over hand,’ gestures, or pointing. In the example of ‘hand over hand’ when teaching cooking, a haptic glove could simulate the action of chopping at an angle. This experience would reduce the necessity of relying on sentential representations, or language to describe this action, that could cause ambiguity. For example, the angle at which to chop and the pressure required to cut the object.

Furthermore, a participant shared their concern with the feeling that technology is developing silos (Figure 5, Tech dev in silos). In this example, of particular note, is the placement at 0 of the 5-point scale on the z-axis, mutual knowledge creation. Addressing the effect of technology being developed in silos, participants discussed the importance of a diversity of perspectives when developing ICTs, this mutual knowledge creation is required to prevent defaulting to internal representations of what individuals with disabilities may need. In addition, a "one size fits one" approach in the development of ICTs was suggested. This model acknowledges the various lived experiences and perspectives of blind and partially sighted individuals, as well as learning styles. Platforms that support varying ways to synchronize via cross sensory cues would increase shared intentionality in virtual work environments.

4.2.2.2 Virtual working solutions: Instructors and staff calibrating a method to foster synchronization when communicating through ICTs

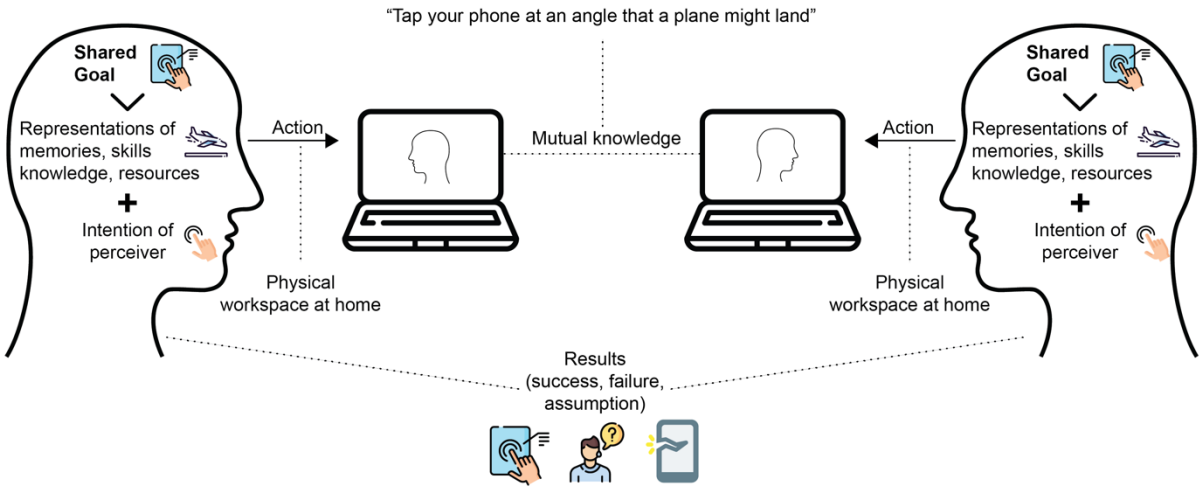


Figure 6: An adapted version of Tomasello et al.'s (2005) shared intentionality demonstrated through an example of training where descriptive language is used to illustrate how to tap on a smartphone

This study found that staff are exercising flexibility in their approach and have adapted trainings to meet the needs of their clients. Adaptations have included incorporating family members, phone calls and incorporating the affordances of virtual communication features such

as chat and polls. It was found that these trainings involved developing a shared language and communication method. In participatory design, "one of the most distinct and influential notions…is that of the language game (Ehn, 1989): bridging the worlds of researchers-designers and users by finding a common "language" or mode of interaction with which both parties feel comfortable" (Spinuzzi, 2005). While in this case it wasn't researchers-designers and users, it was found that in the absence of in-person interactions, trainers found a way to develop a shared language in order to communicate, this increased the perceptual cues available to be perceived in virtual trainings. Establishing this common 'language' between instructors and BPSI is a way to develop a mutually agreed upon toolkit of sentential representations that both parties have access to and reduces the gap in ambiguity that sentential representations can cause when describing concrete objects. Figure 6 demonstrates an example from this study through an adaptation of Tomasello et al.'s (2005) depiction of shared intentionality. In this figure, the shared goal between the instructor and blind and partially sighted client is to tap on the smartphone screen. However, this is a new action for the client and therefore lacks representations to draw on. In order to demonstrate this action, the instructor states "Tap your phone at an angle that a plane might land," this representation on the other hand is one that the BPSI has access to, in this way through the use of sentential representations the instructor and client are able to develop mutual knowledge through which the shared intention is carried out.

This study also found that participants found group trainings less relevant than 1:1 sessions with technology specialists. This example can be interpreted as, group trainings may be more challenging to develop this common "language," or agreed upon sentential representations that reduce the ambiguity in describing how to use your smartphone, for example. Consider how some clients may not understand the angle at which a plane lands, working to create mutual knowledge with many different clients through ICTs, where communication is more challenging, is not as effective in the groups setting. There are increased opportunities to develop this bidirectional toolkit of sentential representations in 1:1 settings, where there are more opportunities to ask questions and infer intentions of the other individual.

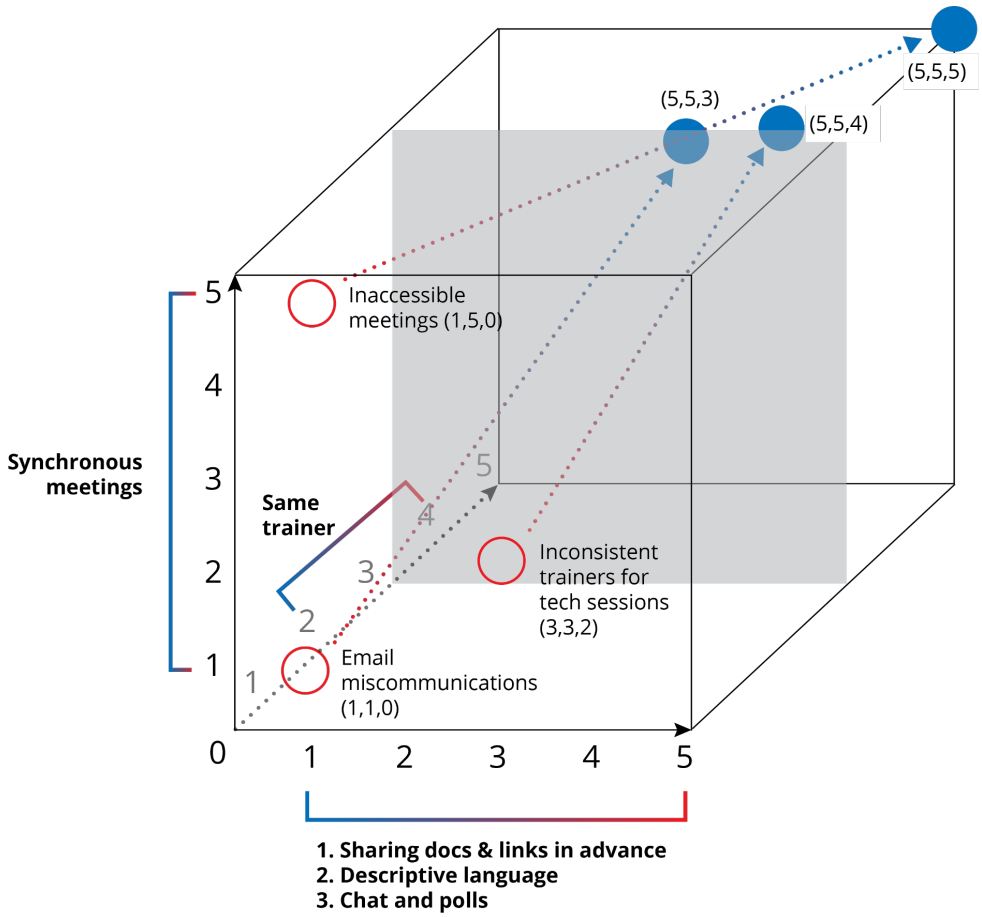


Figure 7: Virtual working solutions (VWS)

This MRP found a number of Virtual Working Solutions (VWS) that staff have been using to reduce conceptual ambiguity when relying more on sentential representations, or language, to compensate for the lack of spatial-topological properties that are more readily accessed in the brick-and-mortar environment. These are workarounds that increase the perceptual cues that are made available through ICTs. In what follows, these workarounds will be demonstrated using the three dimensions of this model:

1. **Increasing spatial-topological synchrony:** In order to overcome barriers created by inaccessible meetings for BPSI, staff shared documents and links in advance, used descriptive language and the affordances of chat and poll functions in virtual communication platforms. In Figure 7, inaccessible meetings fall at 1 of the 5-point scale

on the x-axis, indicating that there is a lack of spatial-topological synchrony in meetings. Sharing materials and links are a way for blind and partially sighted employees to review materials in advance to review the content that will be shared in the meeting, this practice closes the ambiguity gap that is created when sentential representations, descriptive language or chat messages, are used to describe diagrammatic representations that are shared in the meeting, through actions like screen sharing or in a presentation. These strategies to increase spatial-topological synchrony moves the point to a 5 on the 5-point scale of the x-axis.

2. **Increasing temporal synchrony:** Email miscommunications fall at a 1 on the 5-point scale of the y-axis, this indicates low temporal synchrony. Miscommunications may result from the asynchronous format of email, in order to increase the spatial and topological properties conveyed engaging in synchronous meetings would place this at a 5 on the 5-point scale of the y-axis.
3. **Increasing mutual knowledge creation:** Clients shared that consistency in trainers and more personalized learning materials are helpful for their learning. For this reason, inconsistent trainers for tech sessions is placed at a 2 on the 5-point scale of the z-axis, indicating low mutual knowledge creation. These adaptations affect levels of mutual knowledge creation and illustrates that what works for one individual may not work for another. Clients working with the same technology training specialists overtime demonstrates a mutually agreed toolkit of sentential representations of emergent technical language (e.g., an airplane landing as a way to describe the angle at which your finger should tap a smartphone screen), to overcome the ambiguity of diagrammatic representations in training and working through ICTs. Providing the same trainer would increase this example to a 4 on the 5-point scale of the z-axis increasing mutual knowledge creation.

### 4.2.3 Integrating virtual working solutions into procedures and practices at the organization

#### 4.2.3.1 Physical environment bias: The current state of procedures and practices

The physical environment bias refers to the preconception that working in-person and in the same space is required to complete work. Physical environments possess more spatial-topological properties (Figure 5, 5 on the 5-point scale) and involve synchronous interactions (Figure 5, 5 on the 5-point scale), making synchronization of experience higher for the development of shared intentionality. For this reason, physical presence was found to be the default way of thinking and important in the workplace as this "visibility" informed decision making.

There was a lack of accessibility measures and practices found for the virtual environment. Participants shared examples of conferences that worked to create accessible ways to engage in the built environment but failed to provide digital materials in advance. Currently, accessibility audits of virtual environments are found to be reactive and focused on the physical environment. Further, accessibility training offered by organizations focused on the physical environment. There was evidence of defaulting to physical environments to inform the development of policies, accommodations, trainings and accessibility measures. This bias may result from defaulting to environments that are perceptually rich, making the need to rely on internal representations less likely, as seen in Figure 5.

Currently, processes for acquiring equipment, furniture and software for home offices was uncertain. One participant questioned the likelihood of expensive equipment being approved for the home office as it would be in the physical office. There was further uncertainty related to if VWS were the responsibility of the employee or the employer, as well as a need for clarity around expectations related to working hours (e.g., 9 to 5 pm). As demonstrated in Figure 5, these VWS are important for addressing issues of access that have been created as a result of reduced synchronization and shared intentionality. The physical environment bias needs to be addressed to mitigate the reliance on internal representations in virtual environments, as this is

how assumptions surrounding these processes can be formed and mismatches between individual competencies, needs and the work environment can occur.

#### 4.2.3.2 Addressing the physical environment bias

The physical environment bias demonstrates a situation where individuals have focused on the brick-and-mortar workplace as it appears to be more effective in conveying spatial-topological properties that can be perceived through sensory modalities. ICTs, as demonstrated by this study, can be limited in how they convey these properties. In the absence of spatial-topological properties, individuals may have defaulted to preferring these perceptually rich brick-and-mortar workplaces to conduct work and assume that they may be more inclusive based on how they may meet more cross sensory needs. However, the virtual environment has demonstrated many affordances including: the ability to customize the workspace and reducing the necessity to travel for BPSI. The proposed model can be used to better understand the affordances of both environments. The dimensions of the model can be used together or in isolation to describe how synchronization of experience can construct shared intentionality in either environment. This understanding may be particularly relevant to consider the future of work environments post pandemic.

# 5.0 Conclusion

This MRP presented a model for understanding shared intentionality in virtual work environments. In the first part of this MRP the underlying theories and research methods were presented that led to the development of the model. This part demonstrated how shared intentionality, the capacity that enables humans to "act together intentionally, in a coordinated and cooperative fashion, and to achieve shared goals," (Schweikard and Schmid, 2020) is important in the workplace. Additionally, this part illustrated how shared intentionality is constructed through the perceptual cues that individuals pick up from their environment. Larkin and Simon's distinction between sentential and diagrammatic representations was used to describe these perceptual cues (Larkin & Simon, 1987). Finally, how effectively ICTs convey these representations was outlined.

The second part of this MRP introduced and demonstrated the model through the findings that were collected. Built via these findings, it was found that synchronization of experience through the dimensions of this proposed model were required for shared intentionality. These dimensions included: Spatial-topological synchrony is the degree to which spatial perceptual cues, such as through video, spatial audio, or haptics, offer implicit cues, such as gestures, body location, or visual-spatial representations (e.g., diagrams); temporal synchrony is the degree to which real-time interactions clarify intentions; mutual knowledge is the degree to which diverse perspectives facilitate the joint construction of new knowledge and practices. These dimensions were demonstrated through two core case studies that were collected in this study. These case studies ranged from low to high synchronization of experience. Interpretations and recommendations of remedies were proposed through the findings from this study. In addition, due to the scope of this MRP this model was not tested. Future work may focus on benchmarks of measuring synchronization of experience to further extend the understanding of how shared intentionality can be fostered in work environments. This is particularly relevant as the future of work in the post pandemic context requires further exploration. If hybrid work environments become a possibility it will be beneficial to explore whether the individuals that remain in virtual work environments will become further marginalized. Participants expressed that the pandemic afforded flexibility and they were wary of what this may look like if work transitions back to

physical environments in the post pandemic context. This raises questions of whether flexibility is created at the cost of synchronization of experience? This model demonstrates how questions such as these can be explored using the three dimensions of synchronization. The model demonstrates significant value in better understanding issues of digital accessibility of the workplace, processes, and interactions between people and how this deeper understanding can be applied to the inclusive design of innovations and solutions that seek to improve the work environment for BPSI. This model can also be used in more broad contexts in which we socialize, work and learn through ICTs. The virtual and remote transition has affected wide ranging areas of our lives where shared intentionality is present.

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# Appendix A: Interview guide

**Introduction**

**Background/problem:**
Blind and partially-sighted individuals (BPSI) face barriers to finding employment. Only 37.6% were employed compared to 73.6% of adults without a disability (Bizier et al., 2016). These barriers may include inadequate training or experience, unsuccessful past attempts looking for work and accessibility issues. Of these barriers, assistive technologies and training for these technologies have been noted as some of the main barriers.

**Purpose of the interview:**
This interview is one of many research activities to address the problem. Through this interview, the student investigator aims to (1) develop an understanding of the current landscape of assistive technologies (2) barriers to assistive technologies (3) assistive technology training and (4) gain insights for design possibilities of a digital artifact to address this problem.

**Who is involved in the research?**
Erin Lee, Student Investigator, MDes Candidate, OCAD University. This study is part of the student's Major Research Project as part of the Inclusive Design Program at OCAD University. This project is advised by Dr. Peter Coppin, Principal Investigator, Faculty Supervisor, OCAD University.

**Benefits of the research and benefits to you:**
You may find it beneficial to share your lived experience in order to contribute to research on developing accessible assistive technology training.

**Interview Topics**

- Employment
- Employment barriers
- Assistive technology
- Assistive technology training
- Assistive technology needs

**CNIB client questions**

1. Could you describe your experience with seeking employment?
2. What path do you typically take when looking for a job?
3. Could you describe any barriers you feel in the process of seeking employment?
4. Could you describe any challenges you've felt while on the job?

5. Have you had an accommodation provided for you on the job as a result of your disability?
6. If you're comfortable sharing, could you describe a time you've disclosed your disability on the job? How did fellow employees, managers react?
7. How would you describe your familiarity with assistive technologies?
8. Have you attended assistive technology training before?
9. If so, could you please describe your experience with this assistive technology training?
10. Did you find the assistive technology training useful for your employment journey?
11. When you attended assistive technology training was there something about the platform that you found inaccessible?

**Probing questions**

12. Could you describe a time you succeeded in getting a job, why do you think it went particularly well?
13. Could you tell me your thoughts on the key to succeeding on the job?
14. How important would you say assistive technologies are in getting and keeping a job?
15. How do you think assistive technologies could be improved for use in the employment setting?
16. How do you think assistive technology training could be improved for use in employment?
17. Blue sky thinking, what do you think would most greatly impact your experience seeking a job or keeping a job?

**CNIB staff questions**

1. Could you describe your day-to-day job?
2. [If applicable] As a BPSI employment counsellor, how do you think your lived experience contributes to your work?
3. What are some employment services offered by your organization (CNIB, CCB)?
4. What do you think brings clients to your services?
5. What path do clients/talent pool typically take when looking for a job?
6. Could you describe any barriers you feel impact BPSI greatly when seeking employment?
7. Could you describe any challenges you've felt while providing employment services?
8. Could you describe how accommodations and disability disclosure is included in your programming?
9. Have your clients expressed a need for assistive technology training before?
10. If yes, could you please describe the expressed need a little further?
11. What assistive technology training does your organization offer?
12. Did your clients find the assistive technology training useful or important to their employment journey?

**Probing questions**

13. Could you describe a time your client expressed success in getting a job, why do you think it went particularly well?
14. Could you tell me your thoughts on the key to succeeding on the job?
15. How important would you say assistive technologies are in getting and keeping a job?
16. How important is assistive technology training in the delivery of employment counselling to your clients?
17. How do you think assistive technologies could be improved for use in the employment setting?
18. How do you think assistive technology training could be improved for use in employment?
19. Blue sky thinking, what do you think would most greatly impact your experience seeking a job or keeping a job?

**Closing comments**

Thank you very much for your time. Your contribution of experience and knowledge are invaluable to this research and its progress.

Is there anything else that you'd like to add before we finish the interview?

# Appendix B: Codesign session guiding document

This priming document provides an overview of the upcoming co-design sessions as part of a Major Research Project that explores *participatory design of inclusive virtual and remote work environments for Blind and Partially Sighted Individuals (BPSI).*

**Problem space**

The transition to working remotely due to the Covid-19 pandemic has introduced a number of accessibility challenges and implications for Blind and Partially Sighted Individuals (BPSI). BPSI face challenges related to digital accessibility, home office set up, financing equipment and software, remote communications, accessible applications, employer support and management and much more (Ginley, 2020).

**Research question**

1. How can we design inclusive virtual and remote work environments that meet the needs of blind and partially sighted individuals?

**Purpose of the codesign session**

1. Develop a deeper understanding of the needs, barriers and context of the remote work ecosystem for BPSI
2. Highlight pain points of the ecosystem
3. Codesign recommendations and ideas for improvement for the future of remote work for BPSI

**Agenda**

- 10 minutes: Introduction
- 20 minutes: Activity 1: Rose, Bud, Thorn
- 20 minutes: Share back and discussion
- 20 minutes: Activity 2: Insights, Questions, Ideas
- 15 minutes: Share back and discussion
- 5 minutes: Final thoughts: Wrap-up and close

**Prompt questions**

These questions are intended to instigate some thought prior to the co-design session.

1. How do you think the pandemic has affected the way that Blind and Partially Sighted Individuals (BPSI) work remotely and virtually?
2. Could you describe any barriers/challenges that BPSI may face when working remotely and virtually from home?
3. Who are the key players that need to be included in this conversation?

4. What role do you think inclusive design plays in developing new solutions for BPSI working remotely?
5. What role does policy play in the ecosystem?
6. Blue sky thinking, what do you think could greatly impact the experience of BPSI working remotely?
7. What do you think the future of remote work holds for blind and partially sighted individuals?
8. A few other topics for consideration:
    a. Virtual communication and collaboration in the workplace
    b. Digital accessibility
    c. Accessible applications and digital platforms
    d. Employer knowledge
    e. Training and education
    f. Accommodations