Getting Our Brains on the Same Page: The Neural Basis of Effective Communication

Author: Tindar Cyr
Mentors: Lily Tsoi and Diana Tamir
Princeton Social Neuroscience Lab

Abstract:

Social interactions are essential to both our well-being and our advancement as individuals and as a species. However, neuroscientists have been greatly limited in their ability to study these interactions. Up to this point, predominantly unrealistic or contrived social scenarios have been studied in the lab, yet these all too often cannot capture naturalistic experiences. In this study, we aim to create those naturalistic experiences with several real-life tasks that require the careful articulation of instructions along with active listening. From these tasks, we seek to discover the types of interactions and patterns in the brain, with a special focus on neural synchrony, that are characteristic of effective communication.

Introduction:

At the core of human social interaction is the ability to transmit information from one individual to another. Whether that information pertains to semantic facts or subjective feelings, the ability to convey the contents of one's mind has far reaching effects. My mentors Diana Tamir and Lily Tsoi are concerned with the ability to transfer both types of information, and I have primarily been helping them with the former, the ability to clearly convey factual information. Testing an individual's recollection of facts that another individual has told them can intuitively provide a sense of how well the pair communicated. What such a test cannot show is exactly where any lapses in communication may have occurred. The aim of this project is to use behavioral and neuroimaging methods to discover when and where those lapses occur. Conversely it also seeks to discover the behavioral and neural patterns in which the best communication occurs.

To date, neuroscientists have struggled to create realistic social scenarios that accurately reflect real-life interactions. A key obstacle is that the devices used for neuroimaging studies do not allow for much movement, so most designs have major drawbacks. They often make create contrived or one-sided social scenarios.[1] However, newer technologies and methodologies tested by our project co-sponsors here at Princeton have taken steps to overcome these obstacles.[2] Furthermore, the efficacy of the behavioral procedures of research on communication has much potential for improvement. Such behavioral procedures can be broken down into two parts: the actions of the person sending information and the actions of the person receiving information. Both parts are necessary for successful communication and this research seeks to discover the mechanisms by which senders are receivers are interrelated on behavioral and neural levels.

One possible mechanism is the similarity of thought patterns between the sender and the receiver. It is difficult to tell whether two people are thinking about the same things in the same ways, but it has been shown that two people show highly synchronized brain activity when listening to the same speech.[3] Thus, neural synchrony is a strong indicator of mental synchrony, which allows researchers to make indirect inferences about the similarities of two people's thoughts. However, synchrony is not enough for effective communication. If a sender is very unpredictable, the receiver might be able to track with the sender, yet with a significant time lag of about 3-6 seconds.[4,5] The ability to predict what a speaker will say reduces this lag and increases comprehension.[6] Thus, we hypothesize that effective communication requires both synchronization and social prediction.

The specific regions of interest in the brain that we anticipate will have high levels of synchrony are the dorsomedial prefrontal cortex, bilateral temporoparietal junction, and the precuneus. Each of these regions is involved in the high level processing of what is being communicated, so we hypothesize that their activity in particular will synchronize between sender and receiver.[7,8] While other areas may be similarly implicated in the communication, we do not expect them to be synchronized because outside of the meaning of what is being communicated, listening and speaking will trigger very different neurological patterns. To assess the synchrony, we will use ISC, a neuroimaging technique well-suited for measuring synchrony over time. With this data, we hope to learn what brain networks are responsible for effective communication between two individuals, what behaviors correspond to those networks, and how best to bring about both the behaviors and neural patterns.

Methods:

The experimental procedure will have two parts, each focusing on one side of the communication. First, we will have a participant called the sender come into the lab to perform four tasks inside of one of our Siemens 3T fMRI scanners. In each of these tasks, they will describe a stimulus with the intent of helping someone else identify that stimulus at a later time from among a set of choices. The first of the four tasks is called Avatar. In Avatar, the sender will see an image like the one depicted in figure 1. There are twelve different faces that will be used for the study. Each sender will see one of these twelve faces and describe fifteen features including, hairstyle, hair color, nose, eyes, etc. The description of each feature will be recorded in a microphone.

At a later date, a second participant, the receiver, will come into the lab to listen to these descriptions and attempt to identify or recreate the stimulus. For Avatar, both the sender and receiver will see many different possibilities for the feature. The sender will describe the avatar's feature in reference to all of the possible choices.

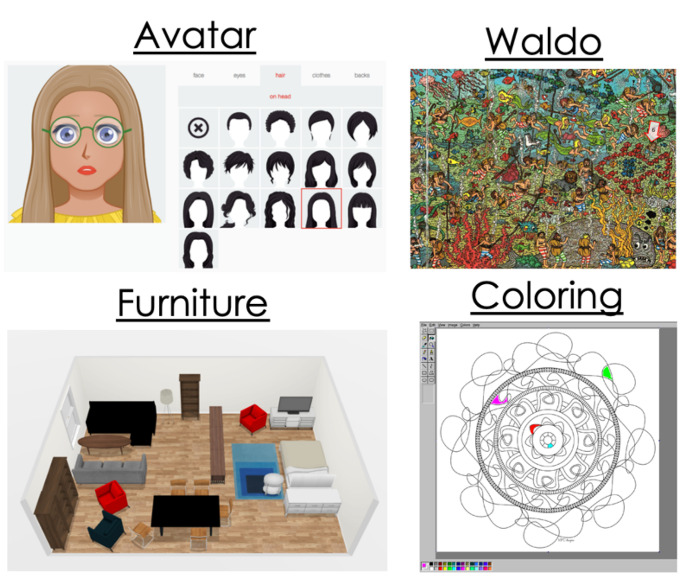

Figure 1: Examples of each of the four tasks from the point of view of the sender.

For instance, a sender might say, “The hair is long, straight hair and goes past her shoulders. It is parted in the middle and falls evenly on both sides”. The receiver would then look at the possible choices for the hair to deduce which one best matches that description.

This process would repeat for each of the four tasks, each with a little bit of task specific variation. The waldo task shows a Where’s Waldo page with an arrow pointing to a specific person in the landscape. The sender will describe the location and characteristics of the person in the landscape, so the receiver can identify them on a page without the arrow. The third task is a coloring task where the sender sees a colored in page from a coloring book. They must describe a specific section of the page based on its location, shape and color, so the receiver can color the page in correctly. The final task is an interior design task where the sender sees a room full of furniture and the receiver sees the same room with the furniture shuffled throughout the room. The sender must instruct the receiver to organize the shuffled room to match their room.

The avatar task is graded in a binary fashion; either the correct feature is chosen or not. Answers to the waldo task are deemed correct if the screen is clicked close enough to indicate the correct character based on the coordinates of the click. The coloring task is graded on whether the correct location is selected, and the correct color is chosen. Finally, the furniture task is graded on the cumulative deviation of the furniture from each correct location. The accuracy on the behavioral tasks will be compared with neural activity data obtained with ISC in the areas associated with social cognition. Furthermore, the neural synchrony of the two participants will be assessed based on the activity in these areas across the duration of the trial.

Hypothesized Results and Significance:

We hypothesize that the sender-receiver pairs that perform the best on the behavioral tasks will also display the greatest neural synchrony. Since the regions of interest for social cognition are high-level processing regions, we hypothesize that the differences in sensory inputs and outputs will not matter for their synchrony. Furthermore, we hypothesize that those pairs with the less lag between their activity will score better on the behavioral tasks because of social prediction's role in effective communication. Conversely, we expect that those that perform poorly on the task will have asynchronous neural activity with long lags between sender and receiver. From these neural and behavioral patterns, we hope to extrapolate what effective senders and effective receivers do to make their communication better than the rest.

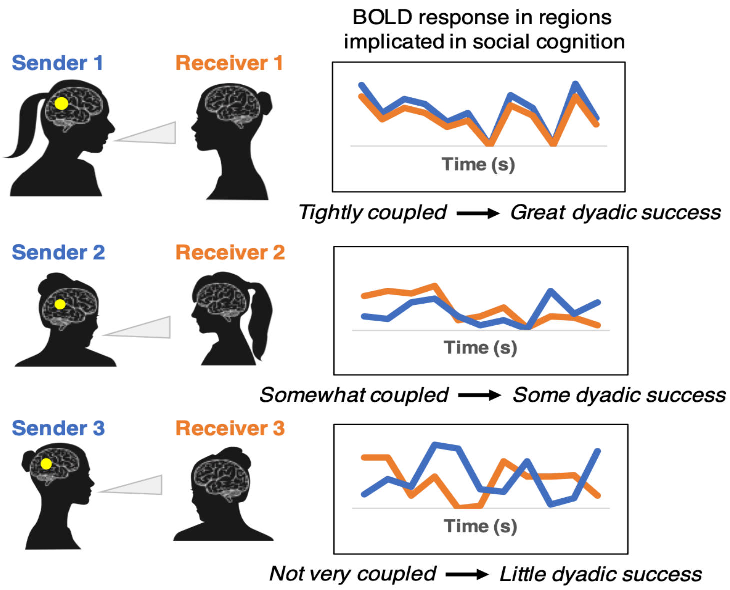

Figure 2: Hypothesized neural synchrony patterns between sender and receiver. The top represents the most effective communicators, the middle represents average communicators and the bottom represents the least effective communicators.

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