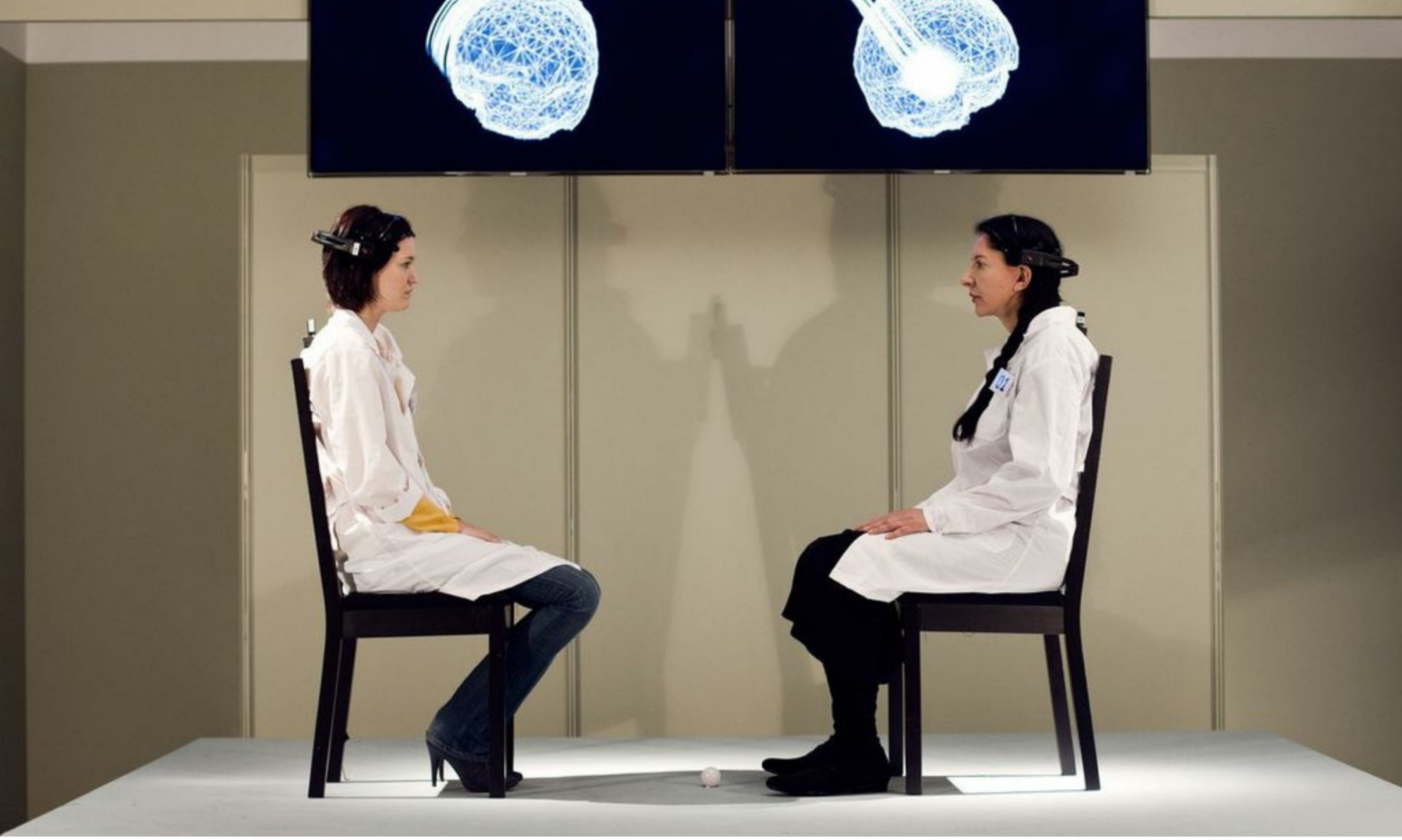

NEURAL SYNCHRONY BIOFEEDBACK, ART, THERAPY, AND HUMAN CONNECTION:

AN INTERVIEW WITH SUZANNE DIKKER

Interview Conducted by J. Alex Faunce, M.A. (Virginia Tech)

Dr. Suzanne Dikker is a research scientist at **NYU Max Planck Center for Language, Music, and Emotion**. She works in collaboration with scientists and artists to produce interactive biofeedback for interbrain synchrony--an increasingly studied phenomenon where two or more people synchronize their brain activity with one another during social interaction. She sat down for an interview with Alex Faunce where they talked about her work, how it has been applied so far, and how it might be applied in the future.

Photo: "Measuring the Magic of Mutual Gaze," by Marina Abramovic, Suzanne Dikker, Matthias Oostrik, and participants of the Watermill Art & Science: Insights into Consciousness Workshop. Copyright Marina Abramovic, 2011. Photo by Maxim Lubimov, Garage Center for Contemporary Culture

AF: Welcome! The first question I think would be a good thing to start with is how you got interested in neural synchrony research.

SD: So my PhD was about predictive coding and language comprehension, and how we process language so rapidly and efficiently. How does top-down modulation of low-level sensory responses help us with faster and more efficient processes through predictive processing? I then did a postdoc at The Sackler Institute for Developmental Psychobiology at Weill-Cornell and became interested in how prediction might not just facilitate language comprehension, but also language interaction processes. When you're predicting each other's speech, does that actually facilitate communication? Probably. We see this when people finish each other's sentences. But in terms of neuroscience, we hadn't really done much research on that. So I started working with Lauren Silbert, a PhD student of Uri Hasson's at Princeton University, who had done some really novel fMRI research on interbrain synchrony in speakers and listeners during storytelling.

At the same time, we began collaborating with performance artist Marina Abramović. This was back in 2010, and Abramović had just finished her performance *The Artist is Present* at the MoMA in New York City, where she sat for 3 months, having eye contact with visitors who could sit with her for anywhere between 2 seconds and 8 hours. We worked with a group of artists and scientists at the Watermill Center, to design an art-science experiment to explore the relationship between the sense of social connectedness and eye contact, and how our brains support this relationship. At the time, there was very little research out there about interbrain synchrony during social interaction [e.g., an article by Guillaume Dumas about joint action synchrony, ***Dumas et al., 2010***, for interested readers]. We restaged *The Artist Is Present* installation art as a neuroscience experiment in a museum in Moscow and collected EEG data from pairs of visitors as they were engaging in silent mutual gaze, and at the same time created a visualization of their neural synchrony in real time. This work shifted my focus away a bit from interbrain synchrony studies between speakers and listeners in the lab, to these much more global questions in uncontrolled experimental situations. Since then I've been trying to work out a way of answering questions that the general public has about neural synchrony.

"We worked ... to design an art-science experiment to explore the relationship between the sense of social connectedness and eye contact, and how our brains support this relationship."

AF: To someone who is just getting started, it's really cool to hear about how people discovered their research niche. You mentioned earlier that you can display neural synchrony in real time... How do you translate physiological information like this into a format that is interpretable to the general public?

SD: So, that is actually a really interesting challenge, I think, because obviously you have to tell a simple but not simplistic story about neural synchrony -- especially when it comes to EEG, where there is so much data.

> Dr. Dikker then showed me a series of videos showing examples of ways she and her team have visualized synchrony in real time. The first video, titled "Measuring the Magic of Mutual Gaze", shows two rotating mesh brains which send waves to one another when interbrain synchrony reaches a certain threshold. The waves pulsated at the particular EEG rhythms that showed the highest synchrony at any given moment, allowing for a visualization of both the strength and frequency of synchrony. Suzanne laughed and said, "This is basically just a moving window analysis, but it feels like doing some magic."

https://www.youtube.com/watch?v=Ut9oPo8sLJw

Another video she showed me, titled Mutual Brainwaves Lab, was a neurofeedback game that Suzanne and her team had used in museum and school settings. The visualization consists of the silhouettes of two heads in profile, faced towards one another and with the physical distance between them determined by the interaction partners' neural synchrony. Optimal synchrony was signaled by the heads overlapping with one another and was rewarded with added points in the game. The heads in the demo video vacillated closer, farther, and closer again, suggesting parallel back and forth changes in the partners' mental intimacy with one another. Suzanne explained that the scaling of the visualization's movement to underlying changes in synchrony was designed to be this dynamic on purpose. "You don't want the brains to always overlap, and you don't want them to always be set apart, so there's artistic interpretation in that respect."

https://www.youtube.com/watch?v=d64SeneJpgY

More recently, the synchrony visualization work of Dr. Dikker and her team has become more abstract and challenging. In a performance piece titled Harmonic Dissonance: Synchron(icit)y, two people dance in front of a black screen. At the beginning of the dance their movements produce whirling white contrails, which then swirl into one another when the dancers' brains are more in sync.

https://vimeo.com/312105834

The visualization that Suzanne and colleagues have used the most is titled Mutual Wave Machine. In this installation, volunteers sit facing one another with a dome shaped projector screen behind each of them. Synchrony is translated into light that people see projected onto the domes, along with real-time video of their partner's face.

https://vimeo.com/96287858

The last video she showed me was a multi-person installation: a tabletop screen that visualizes synchrony between four people. Brain activity from each person seated at the table is represented as a different colored plume of smoke on the table. Flows of the smoke push and pull to represent ebbs and flows of influence between people. When the group synchronizes to a leading person's brainwaves ("the hub", as Suzanne describes it), one color dominates the scene. When the relationship is more reciprocal, the colors swirl together and become one. "This is pretty," Suzanne said, "but it doesn't work for a social science experiment because people are only focused on what's going on with the table."

https://vimeo.com/325295619

AF: It is really interesting to think that this visual feedback could actually alter the neural synchrony itself, just by distracting people from interacting with their partner.

SD: That is an important issue because we are now asking questions about neurofeedback in these kinds of social contexts. Providing people with information about their synchrony can actually help them synchronize more... but how do you create an experience that is not distracting?

AF: So it sounds like when you make neurofeedback into an art installation, you have to consider three levels of different interactions between people. You've got the two partners interacting with each other, you've got the partners interacting with their own neurofeedback, and then you've got the audience watching the feedback.

SD: Exactly. It's very self-referential, which makes it very hard to disentangle all those experimental factors that we're typically interested in as scientists and fully control them.

AF: So the meaning of synchrony changes based on whether and how feedback is delivered. What does neural synchrony mean in more controlled settings?

SD: In the neural synchrony field, a lot of people have the perspective that more synchrony is always better. More synchrony means more cooperation, better attention, etc. But when you look at comparative work with peripheral data, you see examples where people interpret synchrony in a much more careful way. Say for example you're in a therapy session. What would it mean to synchronize at the neural level? But when your client is sharing a traumatic experience, for example, you're not supposed to relive that experience with them and 'spiral'with them, emotionally and physiologically. You're supposed to provide a type of support and emotional buffering, so to speak. So for some signals, maybe synchrony is not really good in this kind of situation. You can also start asking more careful questions about neural synchrony. Are there situations in which less synchrony is indicative of better communication? For example, (**Djalovski et al., 2021**) found lower neural synchrony between romantic partners than between strangers during an empathizing task. Maybe that's because the partners already know each other, and don't need to pay as much attention to understand each other. So the social closeness of interaction partners may change what synchrony means as well--whether it's about understanding someone better, or just paying more attention to them.

"Providing people with information about their synchrony can actually help them synchronize more... but how do you create an experience that is not distracting?"

AF: So synchrony is generally better, but it can depend on context. Often the logic of biofeedback is that, if you can provide accurate feedback to someone, then you can teach them to control the functions they're getting feedback for. Do you think that neural synchrony feedback can be used as a therapy?

SD: We've been thinking about that. What we're seeing so far is that, at least for the measures of synchrony that we've been using, what matters most is what people believe coming into this situation. If people are told that what they're seeing is responsive to their social interaction, then they're going to interact more with each other, which is going to heighten their synchrony. So this feedback context seems to have a big placebo effect. There are many different ways to compute neural synchrony, and it is possible that we need to try out different metrics to see whether another one might be more useful in a feedback loop.

In terms of what we could use neural synchrony for in a therapeutic context… We might be able to develop a synchrony feedback game to motivate children to practice social skills--especially kids who respond better to computer mediated instructions than to human instructions. In terms of more direct interventions, I could imagine recording cortical data during couples therapy, translating it offline into visual feedback for the therapist to examine, and then debriefing people in the way that they've been communicating throughout their sessions.

Going back to our earlier talk about distraction, I don't know if it's useful for a client to get real-time information during the interaction about things that they might be doing right and things that they might be doing wrong. This feedback could be interruptive, distracting the client from the actual human interaction. Say you're having trouble interacting because you're always distracted by your phone... why give yourself another source that you could be distracted by when you are supposed to be paying attention to face-to-face interaction? More subtle feedback might be possible that informs but does not distract, but that is a problem that we still need to try to hash out.

AF: It's both optimistic and frustrating to see that the placebo effect factors so strongly into these effects of neurofeedback.

SD: Yeah I mean, if it works that's great. The next question is, do you need actual neuroscientific equipment to do this? But I think there's actually a chance that you might, because there's a performative/theatrical aspect to this as well. There's still a magical feeling that people get when their brains become visible to them. They feel like their minds are being read while they go into this space with another person, and all the contextual factors bring them to a point where they might be more susceptible to these kinds of effects, placebo or otherwise, facilitating them to connect to each other.

AF: It's interesting that you say that, because it seems like your work has facilitated connections between people in a variety of ways. Through your crowdsourcing neuroscience initiative, you can also work to make neuroscience more accessible in public and educational settings. What does "crowdsourcing neuroscience" look like to you?

SD: The "crowdsourcing" part was a little bit of a buzzword at the time, but we are sourcing data from the crowds, so I suppose it still fits! "Crowdsourcing" in this case means both that we're collecting data from tons of people, and recruiting people to ask scientific questions along with us. We go to museums and have an experiment going for months, collecting naturalistic data from tons of dyads. We also want to encourage a "citizen science" aspect in our work--you're really trying to involve the general public in your questions as much as possible. The way that we frame this is: *Help us understand what makes us socially connect to each other. Why do we feel infinitely more lonely in the presence of somebody that we're not able to connect to? Why do we want to be near people that we love? Are our brains literally on the same wavelength when we feel a connection? What strategies can we use to make better connections?*

"When your client is sharing a traumatic experience, for example, you're not supposed to relive that experience with them... You're supposed to provide ... emotional buffering, so to speak."

AF: It's really cool that you can both get a lot of data and really democratize neuroscience education like this. Do you bring a similar perspective to your work in the MindHive Initiative?

SD: That goes into the democratizing neuroscience aspect of things. Through projects of collecting neuroscience data in classrooms with kids, we've developed a curriculum called BrainWaves, led by Ido Davidesco. The program facilitates helping kids to their own real EEG studies as part of their educational experience. This is a great program but it's also very involved, and therefore less sustainable or scalable. What I'm trying to do with MindHive is to make student-initiated research in brain and behavior more sustainable and scalable.

Also, often school science demonstrations are focused on whether the experiment “worked”-- based on the outcome instead of the questions. One thing that has been very inspiring about the kids in our work is how many questions they ask. It's the research questions that ultimately drive the research program. So we encourage them to generate research ideas in an open science and citizen science framework.

We're pushing to create a portal where different schools implement MindHive at the same time, kids generate their research proposals, which are then reviewed by students from other schools. This gives students first-hand experience with the collective endeavor that science is.

AF: Thank you so much for talking with me today. I’ve learned a lot!

SD: No problem. Good luck with school!

Photo: Suzanne Dikker & Matthias Oostrik, Mutual Wave Machine 2013-present