**Loom History and Current Goals:**

To date, we have created and collected data for two versions of Loom (Loom v1, Loom v2). There is a published conference paper and a journal article in review for data from Loom v1, and now we have to decide what we are going to do with the data from Loom v2. Currently, the goal is to publish findings from the Loom v2 dataset, an autism journal. To do this we must make a leap from the first paper’s finding and say something relevant to the field. The purpose of this document is to find a **potential** avenue of questioning that will drive the analysis and creation of this future publication.

In the first paper, we were able to characterize how a virtual presence affects individual measures of gaze, movement, and arousal in autism. While interesting, due to the novel methodology, the characterization of difference alone does not really answer any questions about how social interaction is differently formulated and performed in autism, which is really the goal of using a dynamic social interaction game like Loom. From Loom v1, we asserted that there are certain instances in movement, gaze behavior, and arousal where timing and degree of autonomic response are different in autistics compared to non-autistics and that most of these instances occur in a social cooperative scenario. It is encouraging that most of the individual findings for movement, gaze, and arousal have been produced before in some regard during smaller uni-measure experiments because most of those studies were not done in VR, so this work potentially adds additional credence to the paradigm as a viable substitute for some avenues of research. The gaze duration data for the view wall is particularly interesting because it shows a *skill* that autistics have for static search and detail detection in the context of a highly dynamic situation rather than a deficit in ability which is most commonly looked for. From our current analysis, this was the only example of autistics being better than non-autistics as the other data for gaze and movement was found to be either statistically similar or autistic people were slower compared to controls. I would like to use the data set from Loom v2 to say something more specific and relevant to the topic of social interaction. Unfortunately, articulating how these autistic characterizations explain anything about their troubles with social interaction is difficult. Some of the reasons for this include direct challenges to the findings like:

1. This is a virtual environment and may not fully mimic a real social interaction.
2. The differences found between the groups are caused by something indirectly associated with social interaction, such as visual or game complexity. *This covariate would have to be present only in the cooperative condition since that is where we see the majority of group differences.*

And more conceptual challenges regarding the nature of social interaction. Simply, it is difficult to describe specifically why autistic individuals are incapable of fluid social interaction when we do not really have a baseline for what comprehensive social interaction is.

**Finding a Research Question that incorporates multiple domains of autism and social interaction**:

Some autistic characteristics are easier to extrapolate as to their effects on social interaction such as, the use of gaze when making (or not making) eye-contact or the lack of accuracy when identifying human emotions and social ques. However, these examples are difficult to contextualize more broadly about social interaction because of the aforementioned lack of specificity on the topic. These predominantly visual and cognitive characteristics of autism could be related to the other autism specific differences that have been reported such as the issues with motor control. Combining these domains is an important step for the autism field because of the high likelihood that there is an underlying reason for both occurrences. This reason, whatever it is, could be a vital piece of information for understanding the challenges that autistic people have with social interaction and developing practical clinical applications. Currently Loom cannot do mechanistic research that would require neuroimaging techniques like EEG or fNIRS (possibly a future addition to the system) which would provide more tangible evidence for a connection to the domains of gaze movement and arousal, but it may not be necessary to at stage and most likely could be used to validate any findings that we make from the current data. Therefore, I believe that my task must now be to find a measure that answers the questions:

**Q1:** How do autistic individuals combine the use of gaze & movement (and possible arousal) differently than non-autistic people?

**Q2:** Do social stimuli impact this combination?

**A Measure Combining Movement, Gaze, and Arousal:**

To understand how individuals with autism are functionally combining multiple domains of action differently than non-autistics, we must find a task and measure that incorporates each of these domains.

Rather than having a standard start and stop to a task/trial, which is the norm. Loom is a game that allows the player to act of their own accord, but it facilitates several movements that players are required to do to complete the game’s objective. It is more useful to say that Loom allows players the freedom to choose the order of their actions, but the individual actions themselves are relatively consistent across players. There may be a question in the future about how the sequencing of actions changes between groups. The incorporation of tasks that are both positively and negatively affected by autism could be interesting to explore. The **intra-game tasks** that Loom currently facilitates are:

* Grabbing a cube on the Play Wall
* Placing a Cube into a Drop Zone
* Checking the View wall for information
* Turning from the Play Wall to the Build Wall

If we want to use some or all of these intra-game tasks as the structure for measurement, we must establish a precise timeline describing when each of them starts and stops. Additionally, we must at least consider previous research that has been done and incorporate it into the measure we are creating. This way, we can reference and expand upon previously established results. A good place to start is the *reach-to-grasp* literature, which is a highly researched movement in autism (and elsewhere) and is a developmental milestone for movement, so there is a direct link to clinical applications (which is good).

This paper: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1693116/pdf/12639336.pdf>

Is a foundational report on the topic of reach-to-grasp in autism. It outlines the kinematic differences of autism as well as a more complex topic, which is the differences in motor planning found in autistic individuals. The kinematic differences that lead to slower movement times are something that Loom 1 was able to show. Although reach-to-grasp can be described as two different movements, functionally, they are happening in parallel. While a person is reaching for an object, they are also preparing the aperture of their hand’s fingers to grasp it upon arrival. This preparation step, termed “motor planning,” is now a full avenue of research in autism due to the differences shown here and in other places.

One possible question involves the use of gaze, head position and hand position, and how each of these three different motor movements are leading the others.

This study

Outlines a potential question about how autistic people are using their gaze and head movement in coordination differently than non-autistic people.

Motor abnormalities in autism (Fournier,Hass,Naik,Lodha,&Cauraugh,2010) have been found in many instances, however there is a large amount a variability in these findings and it is unclear as to why. Obstructed development or interventions could be the cause. Difference in neural physiology have also been consistently observed in autism. Specifically in cerebral hemisperes, caudate nucleus, and cerebellum. Additionally less integration among brain regions have also been found in autism. Decreased connectivity across the motor execution network relative to children with normal neurodevelopment could be one reason for the difference we see in motor control.

These motor abnormalities still do not really get us that much closer to the issues found with social interaction.

**Literature concerning the combination of Movement and Social Interaction:**

# This paper: So close yet so far: Motor anomalies impacting on social functioning in autism spectrum disorder – Casatelli et al

<https://www.sciencedirect.com/science/article/pii/S014976341530258X?casa_token=cuEVAP19BoUAAAAA:nNyS5Ksjwd_sqVBNF6Bg2wBDDzkz6IUJ0JqqNn_F_n92wfyX38tffzihl_g-cKCcDD7v_LMM#bib0095>

Describes terms which could roughly outline a conceptual foundation for the different kinds of connections that exist between social interaction and movement. These terms are and “motor resonance” and “motor interference”

**-Quote:** “Referring to ASD, the first one can impact the ability to directly understand (i.e., motor-based understanding) others’ behavior, whereas the second one may be considered a more general and pervasive motor marker of social anomalies.”

**Motor Resonance:** The type of evidence that is given in the paper for motor resonance is focused on the differences in the motor planning and visual observation of movement that occur in autistic people. For example ([Cattaneo et al., 2007](https://www.sciencedirect.com/science/article/pii/S014976341530258X?casa_token=cuEVAP19BoUAAAAA:nNyS5Ksjwd_sqVBNF6Bg2wBDDzkz6IUJ0JqqNn_F_n92wfyX38tffzihl_g-cKCcDD7v_LMM#bib0115)) is a really cool experiment that uses EMG attached to the mouth muscle to record activation on a task that asks autistic and non-autistic kids to preform two actions. Action 1) Picking up food and putting it in the mouth and Action 2) picking up food and putting it into a bin. The autistic group showed a late mouth activation occurring after the grabbing portion of the action in difference to the non-autistic group who did. Implying that there is some kind of neurological issue affecting the functional activation of movement and impacts motor planning. Interestingly, this study also contained a second “observational” condition where the participants watched someone else do both actions. The non-autistic group showed similar mouth activation while watching some preform the eating action but the autistic group showed no activation while observing either action. Both of these results imply that the autistic group has difficulty visually encoding the goal of an action, which is more pronounced in a purely observational situations. The Casatelli paper also cites another paper:  [Boria et al., 2009](https://www.sciencedirect.com/science/article/pii/S014976341530258X?casa_token=cuEVAP19BoUAAAAA:nNyS5Ksjwd_sqVBNF6Bg2wBDDzkz6IUJ0JqqNn_F_n92wfyX38tffzihl_g-cKCcDD7v_LMM#bib0050) which further highlights this inability to infer intention from specifically motor cues.

A diagram of a autism spectrum disorder

Description automatically generated

This is purely speculation as there is no evidence concretely connecting these concepts, but they could be avenues for future research. The connection of these domains more tangibly, could be a problem that Loom could help address. With Loom, we can measure the free use of gaze, movement and arousal in a highly temporally dynamic manner. In a paper: <https://www.sciencedirect.com/science/article/pii/S014976341530258X?casa_token=cuEVAP19BoUAAAAA:nNyS5Ksjwd_sqVBNF6Bg2wBDDzkz6IUJ0JqqNn_F_n92wfyX38tffzihl_g-cKCcDD7v_LMM#bib0095>

These two examples are given terms while attempting to connect social interaction to movement.