Kinetic Classifications for Assessment of Typical and Atypical Infant Play Behavior with Toys

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> On average, typically developing infants gazed at, touched, grasped, and kicked the instrumented toys more than their atypically developing counterparts.

Introduction

Preterm Birth:
- Affects 1 in 10 infants. Rates are rising.
- Is the leading cause of death for children under five years of age worldwide.
- Can lead to lifelong neurodevelopmental concerns.

The Clinical Perspective:
- Movement capabilities develop along a set of expected milestones in infancy; infants not adhering to these milestones are developing "atypically" and potentially considered at-risk.
- Standard guidelines (*Prechtl* and *BINS*) for measuring movement development rely heavily on the eye of a trained professional, and thus can be inaccessible.
- Infant brain plasticity is high; early intervention into potential delay is crucial for optimal recovery.
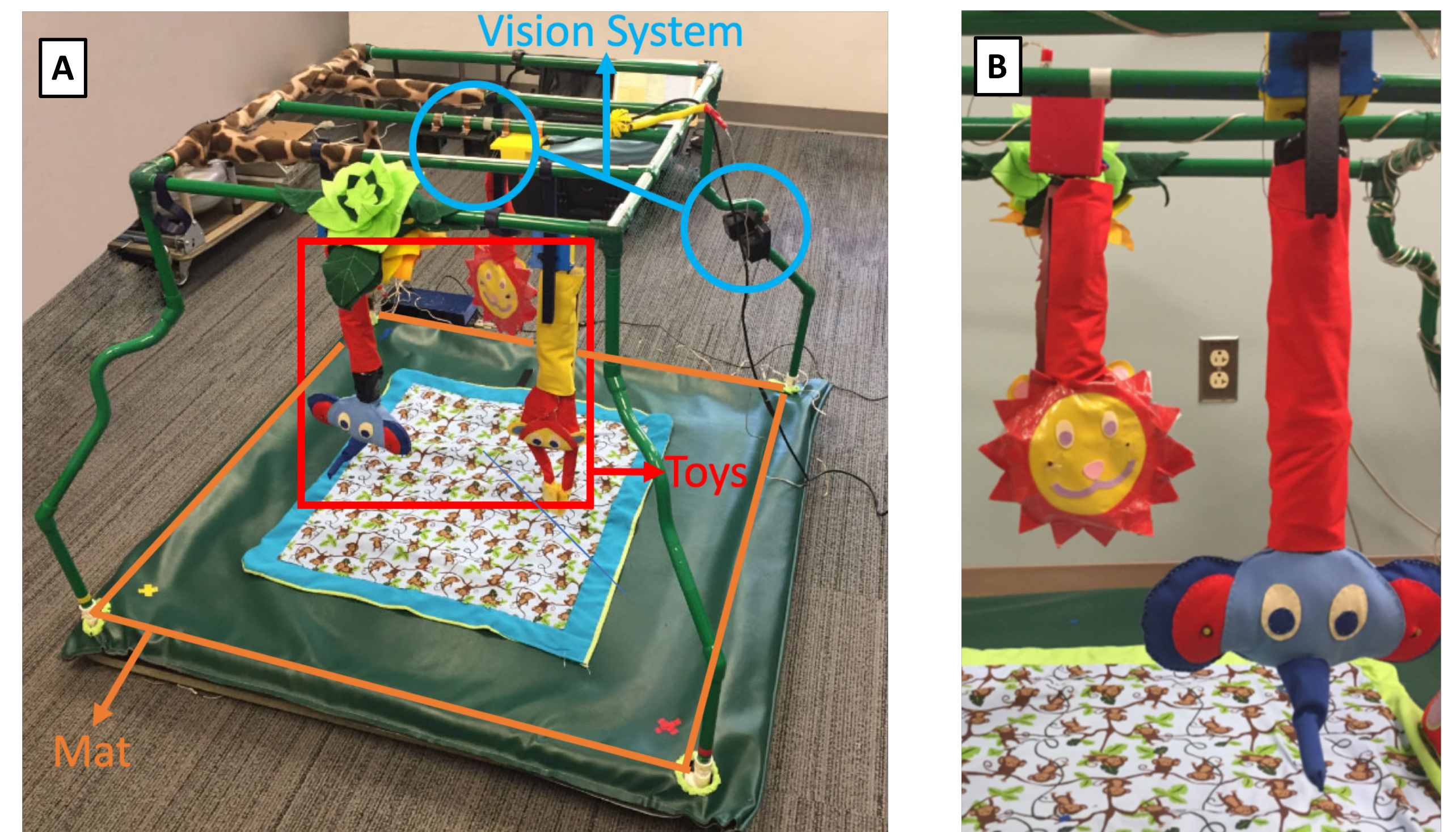
Our Approach:
- Using our Play and Neuro Development Assessment (PANDA) Gym, we developed a set of activity classifications to serve as a metric in quantifying movement patterns across infant populations.

Objective:
- Typically developing infants were expected to engage with the gym and toys more voluntarily, and with greater overlapping of individual interactions, than their atypical counterparts.
- Using video data gathered from the PANDA Gym, is it possible to quantify movement with activity classification patterns from infants as a potential metric in distinguishing atypical from typical behavior?

Activity Classifications

Classification	Definition
Involuntary*	Unintentional; toy does not appear to be the intended target of contact. Interaction usually without visual engagement.
Gaze†	Direct eye contact/attention directed at toy; determined by pupil direction and/or head angle.
Mouth†	Toy touches lips or enters mouth of infant.
Hand Touch†	Physical contact with toy but fingers and/or palm do not close around any part.
Hand Grasp†	Physical contact with toy but fingers and/or palm do close around any part.
Foot Touch†	Contact of foot with toy. Usually more prolonged than a kick.
Foot Kick†	Contact of foot with toy involving greater force than a touch. Usually shorter term than a touch.

Table 1. (left) Collection of activity classifications used to evaluate each infant.
*Involuntary interaction; †voluntary interaction.

Figure 2. (below) A. Infant visually engaged with the lion toy; **B.** Infant not visually engaged with lion toy but foot made contact with toy in an involuntary manner; **C.** Infant visually engaged with toy and grasping trunk while touching ear (simultaneity); **D.** Infant visually engaged with toy while touching with foot (simultaneity)

Visual Representations:
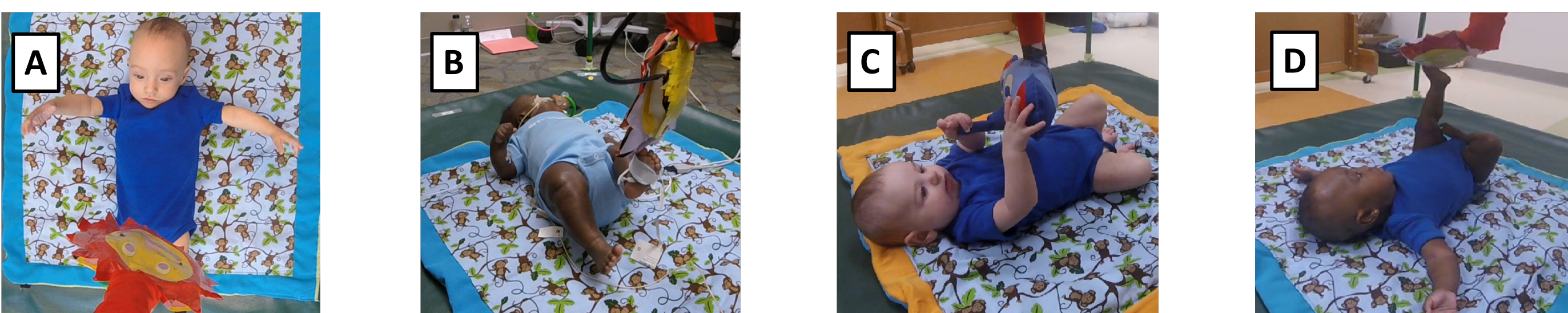
Methods

Procedure:
- From an initial pilot study of 34 infants, subjects 6 months of age or younger were selected (n=15) for testing
- 2-minute video samples from upper and lower interaction sessions were coded in *MaxQDA* for interaction types and lengths using the developed activity classifications
- Researcher was unaware of infants' health statuses at time of coding

Inter-Rater Reliability for Code Accuracy:
- Using an intraclass correlation (ICC) two-way mixed effects model in *SPSS*, agreement coefficients were 0.978 and 0.990 for the elephant and lion, respectively, across two independent researchers for ¼ of the infants

Data:
- Data was analyzed for each activity classification, and the total interaction time per activity was calculated. The total interaction time was summed across all activities and then averaged across all infants.
  - **Ex:** if an infant simultaneously gazed at, touched, and grasped the elephant toy for one 10 second time span, the total sum of all interactions for that time span would be 30 seconds.

Acknowledgements

Play & Neuro Development Assessment (PANDA) Gym

Figure 1. (above) A. Full setup of the PANDA Gym. **B.** Elephant toy on left and Lion toy on right; used for upper and lower body play engagement, respectively.

Build:
- 3D-printed sensorized gym and sensitized play toys built to mimic an infant's play gym environment
  - Pressurized mat, sensitized smart toys, and GoPro cameras positioned to give top and side views
  - give user measurements of infant interaction data

Results & Discussion

| Infant Group	Voluntary Interactions (s)			Involuntary Interactions (s)		
	Total	μ	σ	Total	μ	σ
Typical (n=7)	1,823.20	260.46	118.03	80.60	11.51	8.34
Atypical (n=8)	337.70	42.21	51.40	117.60	14.7	16.47

Table 2. (left) Overall interaction time totals and metrics.

The data in **Table 2** (above) represent total interaction times for both the elephant and lion toy combined, for each the typical and atypical infant groups. This data is further classified by toy in the charts below.
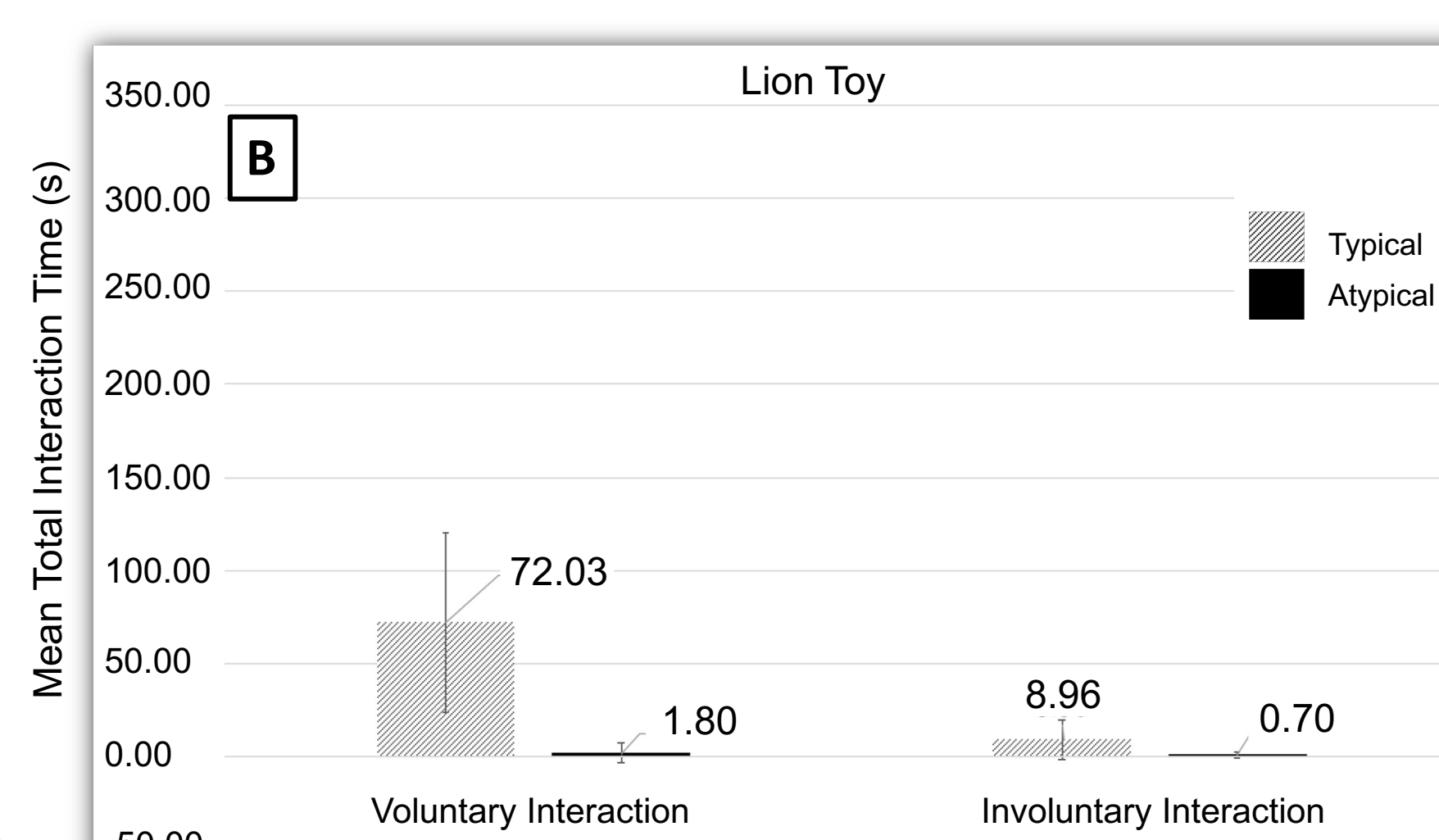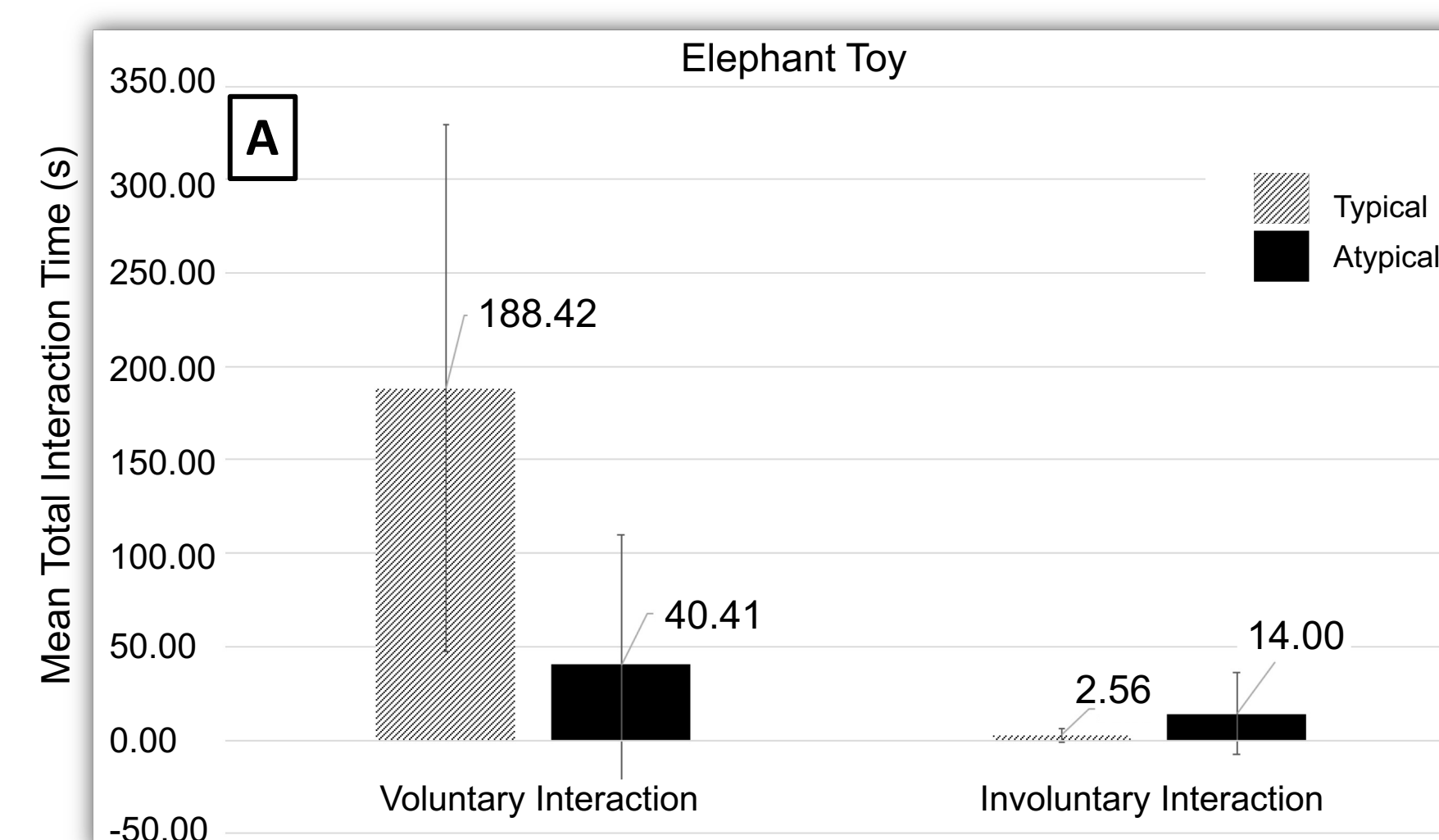
Upper Body:
- Typically developing infants engaged more voluntarily with the elephant but less involuntarily than the atypical infants

Lower Body:
- Typically developing infants engaged more voluntarily and more involuntarily than atypical infants

Notes:
- Typically developing infants had 6:1 more voluntary interactions than their atypical counterparts with the elephant toy
- The lion toy engaged less interaction overall, possibly due to the general nature of infant movement development at this age
- The greatest amount of simultaneous/overlapping interactions occurred in the typically developing infants

Figure 3. (left) Total interaction times for preterm and full-term infants with **A.** the elephant toy; and **B.** the lion toy

Conclusion

Typically developing infants, on average, engage with their surroundings (gym and toys) more than their atypical counterparts, and with greater overlapping of individual interactions. This is especially true for voluntary interactions, and for upper body engagement. Although atypical infants were shown to outperform typical infants marginally in some trials, they overall don't engage as frequently with their surroundings/the toys as typical infants. Any outlier scenarios were clear and didn't drastically affect overall coded interaction data, but further analysis of all infants in initial pilot is necessary to confirm. For the purposes of this study, all activity classifications were coded and analyzed together. Future testing will explore the efficacy of separating gaze and mouth coded interactions from the other motor activities in both procedure and data analysis.