# Kinematic development of infant-mother interactions during specific tasks


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## Introduction

Everyday social projects exhibit regular action patterns structured by their motor goals. Shared understanding is developed in infancy in participation in common motor projects by learning anticipations of their motor intention, such as during feeding, being picked up or put down, and in play [1]. Co-operative, participatory games and rituals enacted every day by mothers and babies likely establish distinct, culturally specific motor styles. Generation of non-verbal embodied understanding is dependent on *intent participation*, and requires co-ordination and contingent timing of actions from both mother and baby [2]. How infants develop social anticipations and co-ordinated movement to interact with others is a fundamental question for cognitive sciences, and for our understanding the embodied basis of cultural learning.

In this study, we examine the action patterns of mothers and their babies from Japan and Scotland during every day games and rituals (Fig. 1). Goal-directed movements within these are analysed for their prospective control of action using General Tau Theory, a mathematicopyschophysical theory of prospective perceptual control of movement shown to be universally basic in animal motor control [3,4].

## Aim

The aim of this study is three-fold:

(a) to computationally determine perceptuomotor control variables employed in mother-infant interactions and the action patterns exhibited at different stages of development;

(b) to determine cultural differences in motor style between Japanese and Scottish mother-infant pairs; and

(c) to develop an automated kinematic model for reliable data analysis of mother-infant interaction.

## Methods

Study design: Observational study

Sample size: 10 mother-infant pairs from Japan and 10 mother-infant pairs from Scotland at 6 and 9 months of age

Measurement tools:

- 12-camera Vicon Nexus system (100 Hz) (Oxford, UK), University of Strathclyde
- 8-camera Optitrack system (100 Hz) (NaturalPoint Inc, USA), Waseda University

Experimental procedure:

All pairs performed three different tasks:
(i) picking up and putting down the baby
(ii) feeding with a spoon,
(iii) ticking in free play.

Data analysis:

Trajectory data of action effectors, namely the mother's hands, were analysed for goal-directed kinematics and tau perceptuomotor control variables. Baby motor control and development was studied through kinematic analysis of mainly the head and torso and secondary upper and lower limbs.

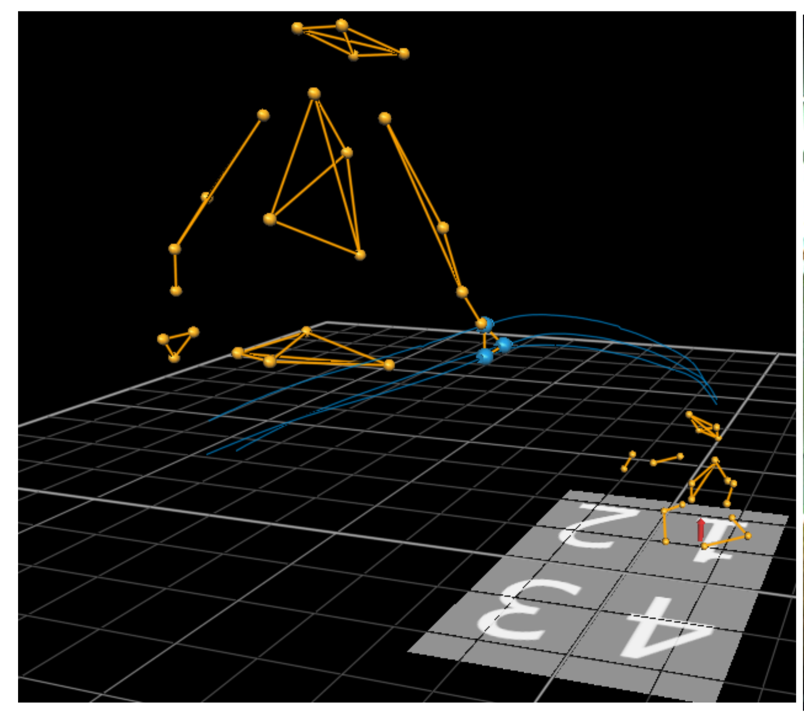



**Figure 1.** Vicon workspace & video output during pickup task.

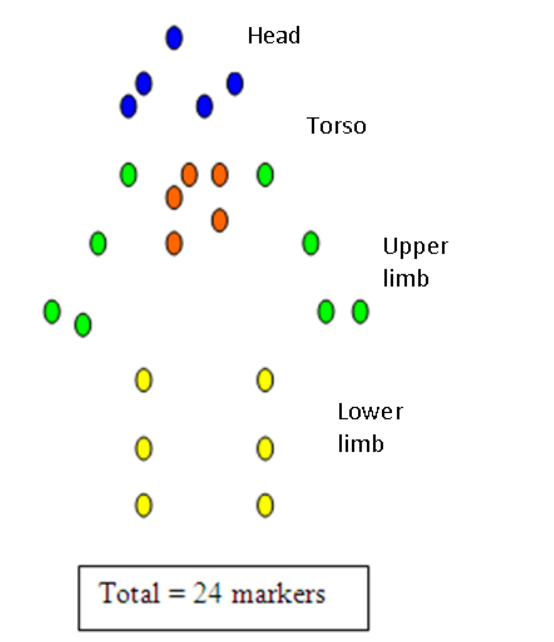
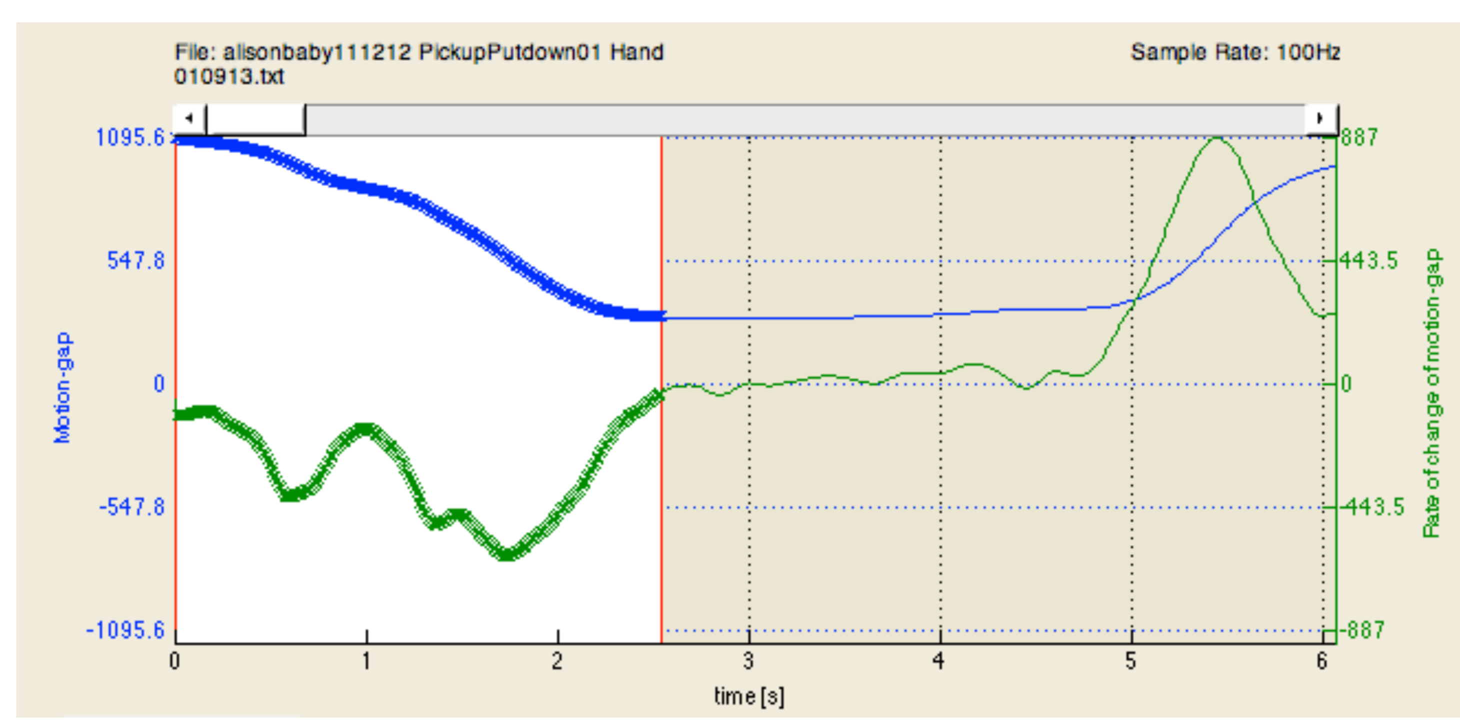



**Figure 2.** Baby marker configuration.




| action unit | T_start(s) | T_end(s) | Duration(s) | X_Start | X_end | Amplitude | PeakVel | PeakVelPos(s | R_Squared | Percentage | N_gaps | k |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.01 | 2.54 | 2.53 | 1094.44577 | 298.62754 | 795.81823 | -617.84467 | 1.74 | 0.95163 | 51.57 | 4 | 0.62027 |
| 2 | 0.01 | 0.15 | 0.14 | 1094.44577 | 1079.71063 | 14.73514 | -110.73761 | 0.03 | 0.95186 | 66.67 | 1 | 0.48881 |
| 3 | 0.16 | 0.99 | 0.83 | 1078.75974 | 874.45112 | 204.30862 | -405.59771 | 0.61 | 0.95704 | 88.1 | 1 | 0.5424 |
| 4 | 1 | 1.47 | 0.47 | 872.86501 | 710.94331 | 161.9217 | -504.73796 | 1.38 | 0.95046 | 83.33 | 1 | 0.6637 |
| 5 | 1.48 | 2.54 | 1.06 | 706.28096 | 298.62754 | 407.65343 | -617.84467 | 1.74 | 0.95076 | 83.18 | 1 | 0.17914 |

**Figure 3.** Tau analysis of the mother's right hand displacement toward the infant (blue trajectory in Fig. 1).

**Graph.** Blue line shows the straight-line distance from the point of contact on the baby. Green line shows the time derivative (velocity). Highlighted area in white shows displacement toward the baby analysed for tau coupling.

**Data.** Tau-g coupling values for the highlighted regions showing calculations for the full action (1) and for its subunits (2-5). Low percent of the full action coupled (51.57%) suggests the mother's approach was segregated into steps. High percent coupled for subunits 3-5 suggests these units were controlled individually – a possible marker of cultural style or developmental stage.

## Results

The kinematic model for the baby consisted of 24 markers forming two segments (torso, head) and hinge joints for the upper and lower limbs. Motor development and control of the head and torso were studied while simple angles and coordinates can be obtained from the upper and lower limbs for trajectory analysis.

Tau analyses of the mothers' action patterns in everyday tasks resolves perceptuomotor control strategies employed. Differences in cultural and developmental strategies are measurable.

## Discussion

This projects advances understanding of embodied cultural learning. It is the first study to use 3D motion analysis to study culturally specific kinematic interaction patterns in child development.

Data analysis will now proceed to compare Japanese and Scottish kinematic patterns to identify culturally specific differences evident in the first months of a child's life as a developmental precursor to more patent shared action pattern differences in adult life.

General Tau theory provides the theoretical framework which enables us to investigate the fundamental properties of motor control and development.

## Conclusions

- Use of optical systems for infant kinematic analysis is challenging; a minimum number of markers can be used to avoid marker occlusions and baby distractions.
- Motion analysis of kinematic and perceptuomotor control differences between cultures and developmental stages is possible.
- Development of a screening tool for early developmental problems is also possible.

## References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