Research Motivation: Dynamical Change in Infant Visual Preference

- Correlation between action perception and production
  - Infants’ ability to understand the goal of other person’s action correlates with their ability to perform the action. [Sommerville et al., 2005; Daum et al., 2011; Kandola & Itakura, 2011]
  - Infants’ preference for others’ motion correlates with their motor ability. [Sawafuji et al., 2008; Hauf & Power, 2011; Hauf, 2013; Lewkowicz & Hansen-Tift, 2012]

- Familiarity vs. novelty preference
  - Factors that influence infant preference:
    - Age: younger ⇒ familiar, older ⇒ novel [Hunt, 1963; Weekford & Cohen, 1973]
    - Familiarization time: shorter ⇒ familiar, longer ⇒ novel [Hunter et al., 1982; Hunter, 1983; Hunter & Ames, 1988; Rose et al., 1982; Roder et al., 2000]
    - Complexity of stimuli: complex ⇒ familiar, simple ⇒ novel [Hunter et al., 1983; Caron & Caron, 1966; 1969]
    - Affective reactions to stimuli: positive ⇒ familiar, neutral ⇒ novel [Nachman et al., 1986]

- Complexity of stimuli: complex
  - Infants’ ability to understand the goal of other person’s action correlates with their ability to perform the action. [Hauf & Power, 2011; Hauf, 2013; Lewkowicz & Hansen-Tift, 2012]

Our Interpretation of Behavioral Studies

- Preference for crawling & walking point light display (PLD) [Hauf & Power, 2011; Hauf, 2013]
  - Visual stimuli: PLDs of crawling/walking adult
    a) Normal version
    b) Phase-shifted version (violated body constraint)
    c) Scrambled version (no body constraint)
  - Our interpretation: Infants prefer stimuli producing moderate sensorimotor prediction error.
    - e.g.) Prediction error of crawling stimuli:
      - Non-crawling infant (6.5 m: a = moderate, b = c = too large)
      - Crawling infant (9.5 m & 13.5 m: a = too small, b = moderate, c = too large)

- Preference for mouth of speaking person [Lewkowicz & Hansen-Tift, 2012]
  - Audiovisual stimuli: Adult speaking native/nonnative language
    - Attention to mouth vs. eyes
    - Our interpretation: Infants look longer at the mouth when it produces moderate sensorimotor prediction error.
      - 4-8 m: mouth = too difficult
      - 10-12 m: mouth = moderate prediction error
      - Adult: mouth = too easy
    - Nonnative language increases prediction error about the mouth in older infants and thus induces attention shift to it.
    - Sound noise too. [Huang et al., 2013 in Japanese]

Our Hypothesis: Prediction Error Determines Infant Preference

(1) Infants learn the predictor (the forward model) of the sensorimotor system through development.

(2) Infants have a fixed preference function: higher preference for a moderate prediction error, and lower preference for a smaller/larger prediction error.

- Early Large prediction error ⇒ Low preference (too difficult)
- Moderate prediction error ⇒ High preference (learning)
- Late Small prediction error ⇒ Low preference (too easy)

- Infant preference changes with age because of the gradual decrease in the prediction error (i.e., sensorimotor development).

Conclusion and Discussion: Potentials of Prediction Error Hypothesis

- Dynamical change in infant visual preference is modeled by sensorimotor prediction error.
  - Infants seem to acquire various cognitive functions (e.g., self-other discrimination, imitation, altruistic behavior) through the minimization of prediction error. [Nagai, in press]
  - Visual preference based on prediction error enables infants to developmentally shift their attention from easy to difficult events with their age. Maximizing learning progress [Schmidhuber, 1991; Vigorito & Barto, 2010, Oudoyer et al., 2000, 2010] 
  - Different attention of ASD children [Pephyrey et al., 2002; Klein et al., 2002] and chimpanzees [Myowa, et al., 2012] might be caused by their preference for more predictable events.

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