Mismatch between maternal voice and face disrupts interaction between 6 month-olds and their mothers

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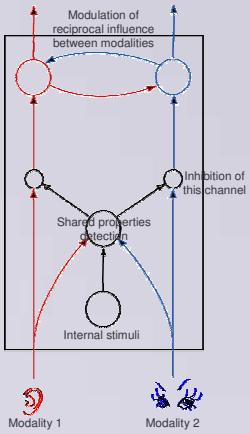
Very early in life, infants discriminate between facial and vocal expressions and engage in bi-directional infant-adult interactions. We do not know much however about the role of an integration of visual and auditive information on the development of such interactions. Since vision and sound constitute two channels of energy exchanges in an interaction loop, we are currently developing a general model of coupling between dynamic systems (Prepin, 2003). This model predicts similar behaviors of the infant facing her incoherent mother or an incoherent stranger. To test this hypothesis, we used our live-replay-live teleprompter design in two experiments. In each experiment we presented to six-month-olds three conditions of interaction with their mother: 1) the infant faces both contingent face and voice of her mother; 2) the infant faces her mother's contingent voice and either her mother non-contingent face (in first experiment) or a stranger non-contingent face (in second experiment), and 3) contingent condition again. The decrease of smiles and increase of motor signals of protest and stress only during the second condition of the first experiment support the hypothesis of a strong emotional reaction to mother's incoherence disrupting the ongoing interaction.



Our model of intermodal integration

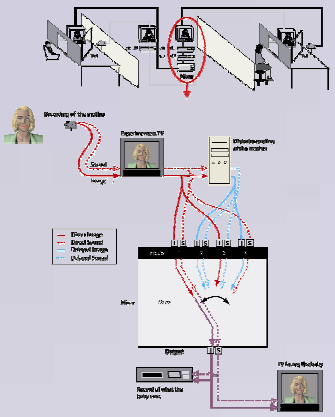
We suggest that a bimodal system is able to distinguish co-occurring flows of information from co-variing ones if it detects shared a-modal parameters, such as speed, rhythm, periodicity, intensity of flows that reflect their inherent tight connections.

The shared properties detection module compare the two incoming flows of information corresponding to the two incoming modalities:

a) If the rate of shared properties is above a threeshold, the guess is that the two flows are expected to come from the same system. The "shared properties detection module" does not inhibit any of both modalities pathways, the modalities are processed complementarily and reinforce each other.

b) If the rate of shared properties is below the threeshold, the guess is that the two flows are expected to come from two independent systems. The "shared properties detection module" choose a winner and inhibits the other. (If both modalities are taken into account even if they are incoherent, that must generate contradictions and instability in the system).

Notice that the "shared properties detection module" detects shared properties between incoming modalities but also the shared properties with internal stimuli: if incoming modalities do not share properties, the selected modality is the closest to the internal stimuli, it might be the contingent one.



Multimodal interaction

Given a system *Syst.1* which receives simultaneously information from different channels, how will this system process the two flows?

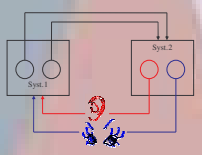
Syst.1, *Syst.2* and *Syst.3* are dynamic systems exchanging energy (as shown by arrows) through different channels: the visual channel where facial and bodily motor outputs of one system are visual inputs for the other(s), and the auditory channel, where vocal and verbal outputs of one system are auditory inputs for the other(s). Those two channels are symbolised by red and blue colours. *Syst.1* receive flows of information from both channels. Two interaction situations can be distinguished:

a) The two information flows come from a unique source (*Syst.2*), that receives *Syst.1*'s outputs and is thus contingent with *Syst.1* (i.e. *Live* conditions in our experiments).

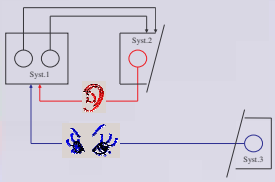
b) The two information flows come from two independent sources: *Syst.2* contingent with *Syst.1*, and *Syst.3* that does not receive any ouput from *Syst.1* or *Syst.2* and is thus totally non-contingent (i.e. conditions *Contingent voice of mother coupled with non-contingent face of mother or of stranger*).

Is the young infant able to extract common properties so as to distinguish between co-occurring information that comes from two independent sources and coherent or incoherent co-occurring information that comes from a unique source?

a) Two systems interacting using two information channels



b) Three systems. The third is totaly independant from the others

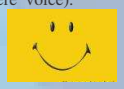


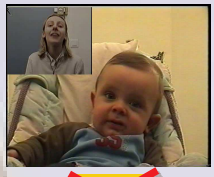
Predictions

First experiment

a) Contingent mother's face and voice: information flows are coherent and contingent: the model predicts a multimodal processing and alert interaction.

b) contingent mother's voice and non-contingent mother's face: the model predicts similar behavior if facing two independent systems with a preference toward the contingent source (here voice).



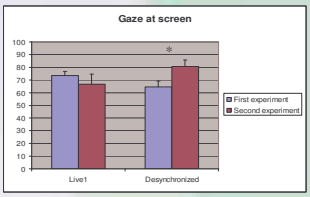


Second experiment

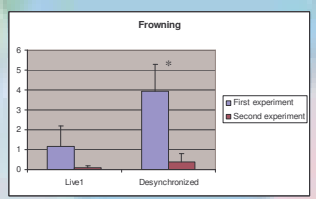
a) contingent mother's face and voice: : information flows are coherent and contingent: the model predict a multimodal processing and alert interaction.

b) contingent mother's voice and prerecorded stranger's face: the model predicts similar behavior than with two independent systems.

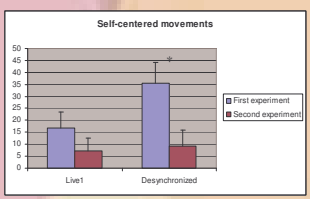
Results



The live condition does not reveal any significant difference between the two population of six-month-olds.



The mismatch between contingent voice and non-contingent face of mother disrupts the interaction whereas the mismatch between contingent voice of mother and non-contingent face of stranger does not.



The incoherent mother generates stress effects, thus showing that expectancies for contingency are violated . By contrast the coupling of mother's voice and stranger's face, though unexpected, has no stressing effect, thus showing that the coupling is seen as coming from different sources and does not violate interactive rules.

Concluding comments

Our model correctly predicts the different interactive effects of a contingent Vs. non contingent mother but fails to distinguish between cases of bimodal mismatch coming from the same source or from different sources. What is lacking in the model is an account of the capacity of system 1 to expect another system to be bimodal, thus sending coherent flows with shared properties. Taken together, our findings show that 6-month-old infants have formed the concept of mother as an intermodal entity whose sensorial outputs should cohere in a contingent bimodal response to the infant's behaviour, and clearly distinguish a dysfunctioning intermodal entity from co-occurring sensory messages originating from two different sources.

Nadel, J.,Prépin , K;, & Okanda, M. (2005). Experiencing contingency and agency: first steps toward self-understanding in making a mind? *Interaction studies: Social behaviour & communication in biological and artificial systems*, 4, in press