

Imitation and the Generative Mind

Jacqueline Nadel

CNRS Centre Emotion, Pierre & Marie Curie University, ICM,
La Salpêtrière Hospital, Paris, France
jacqueline.nadel@upmc.fr

Abstract. In its perpetual capacity to imagine, create and revisit artifacts and representations, human mind is the perfect example of generativity. Yet if we agree with Epstein (1996)'s theory of generativity, new ideas result from inter-connections among old ones. That is, cultural knowledge heavily influences our individual minds. In this line, our minds need meeting other minds to generate innovation. I will argue in this article that the basis of a generative meeting between minds is imitation. This proposal is developed against the well-established reputation of imitation as an idiotic behaviour stifling creativity.

Keywords: imitation, generativity, flexibility, development, brain dynamics.

1 Introduction

An ancient tradition hinders the reputation of imitation. This tradition comes from the great philosopher Plato. Plato described imitation as dangerous because it stifles creativity, hampers the development of personal identity and disrupts the perception of other people as unique beings. Girard recalls in his book, 'Things hidden since the foundation of the world' (Girard, 1987), that in certain cultures, one child out of every set of twins would be killed, as would a son who looked too much like his father. Who exactly was at risk, in a world where such little importance was given to the concept of individuality? Surely the danger was not for the imitator but rather for the social group, where too close a physical resemblance might have caused confusion about roles in the community (Vernant, 1983). It remains that for centuries and centuries, imitation has been an object of contempt. For instance, Piaget (1945) called "intelligent imitation," a reproduction that is not stuck in the present (i.e., imitating an absent model), nor is it stuck with what the infant already knows how to do; thanks to representation, an action can be performed without requiring a direct perception of it. In sum, according to Piaget's theory of intelligence, simply doing what the other does is not 'generative'. The aim of this paper is to demonstrate that this view does not take into account the capacities required in order to imitate, and the generativity it allows to brain, behavior and mind.

2 Generativity and the Meeting of Minds

Generativity is described via Wikipedia as ‘a self-contained system from which its user draws an independent ability to create, generate, or produce new content unique to that system without additional help or input from the system's original creators’. In its perpetual capacity to imagine, create and revisit artifacts and representations, human mind is the perfect example of generativity. As a consequence, human mind inspires generative models in computer modelling. Linguistic theories such as the famous Chomsky's theory have emphasized the unique role of language in the expression of our generative structure of mind (Chomsky, 1985). Language offers us the means to express our thoughts through unique pieces of linguistic creation. These pieces are built thanks to a generative and transformational grammar that possesses compositionality (Dennett, 1971) and provides us the capacity to construct complex messages. Chomsky's model of generative syntax contributes to the theory of mind's perspective. It meets probabilistic generative models that aim to infer invisible variables of the investigated phenomenon on the basis of visible variables. Indeed it is what we do each time we infer the unobservable mental states of others on the basis of probabilistic computation on observed events. Now suppose we adopt Ziffrain (2008)'s definition of web generativity as “a system's capacity to produce unanticipated change through unfiltered contributions from broad and varied audiences.” Then, we have to broaden our definition of a system to the assembly of two or more persons. In this view, our mind possesses means to produce generativity proviso it works in concert with other minds.

3 Social Cognition and Social Interaction in Cognitive Sciences

This way of thinking is in line with a burgeoning field in cognitive and neurocognitive sciences. After a long focus on mentalizing processes studied in subjects in isolation, cognitive sciences are now turning to analyze the role of social cognition in online social interaction. Yet the need for a clear-cut distinction, at the theoretical and methodological levels, between the generic term of social cognition and the specific phenomenon described as social interaction is not shared by all specialists in the field. A traditional cognitive interpretation holds that the brain is simply entering another mode of functioning when immersed in a social interactive context. Of course social interaction mostly involves social cognition as an underlying process by which humans understand, anticipate, or infer the intentional behavior of others. Moreover, it is the place where social cognition most frequently occurs in everyday life. Yet social interaction is a specific online phenomenon which cannot be considered merely as a category of inputs to be processed by individual mechanisms (De Jaeger & Di Paolo, 2012; Dumas, Martinerie, Soussignan & Nadel, 2012). The reason is that social interaction is a co-regulated coupling between at least two agents who are mutually influencing each other. This definition and the underlying dynamical theory are currently gaining ground in social neuroscience against a solipsistic view of the generative mind.

4 Developmental Psychology, Imitation and the ‘Two-Person’ Stance

Inspiration for an alternative approach to social interaction comes from developmental psychology, in which, beginning in the 1970s, attention turned to studying real-time dynamic interactions involving two or more partners. The emphasis was then put on dyadic variables (Nadel & Camaioni, 1993) such as imitation, joint attention, turn-taking and coregulation, various aspects of which have been referred to as coregulation (Fogel, 1993), synchrony (Trevarthen, 1977), or harmonization (Stern, 1977). The concept of coregulation suggests a dynamically changing individual during the process of transaction with others. In the same line, cognition is considered to be constantly evolving in dynamic interactions (Varela, Thompson & Rosch, 1991).

Immediate imitation is often defined as a social behaviour leading to the individual benefit of learning. There is however another function of imitation which fits well the two-person perspective. Studying spontaneous imitation in an online meeting of peers aged 12, 15, 18, 24, 30, 36 and 42 months, we have shown that young children take advantage of the two facets of imitation to get two roles (imitator and model) that they switch to take turns (Nadel & Butterworth, 1999). Indeed the dynamics of imitation makes it a genuine communicative system which presents the three parameters of any interactive system: synchrony, joint attention and turn-taking. Like in conversation, roles are exchanged smoothly on the basis of a coregulation. Prepin and Revel (2007) have shown that two oscillators facing each other loose progressively their specific tempo and adopt a common tempo different from their own. Similarly, young children imitating each other form a system which generates novel common actions differing from the repertory of action of each partner: it is literally a generative two-person system. Thus, it appears that imitation serves both the traditionally-recognized function of promoting skill acquisition and a previously unacknowledged interactive function (Andry, Gaussier, Moga, Banquet & Nadel, 2001).. Where does this double function of imitation emerge from?

5 Neonatal Imitation and the Foundation of Social Interaction

Social interaction in its basic foundation is well represented by imitation from birth on. Literally from birth, typical neonates are able to imitate a tongue protrusion (Meltzoff & Moore, 1977). They are even able to imitate a tongue protrusion presented on a screen (Soussignan, Courtial, Canet, Danon-Apter & Nadel, 2011). It is not a prowess: Protruding tongue is already in the motor repertory of foetuses of gestational age 25 weeks (Piontelli, 2010). The prowess is that they are able to use their motor repertory according to their perception. So doing, they relate their motor patterns to the others' motor patterns. Moreover, the newborns match more and more exactly the perceived stimulus after repeated attempts, which shows that they are able to modulate their motor repertoire (Soussignan et al, 2011). Thus neonatal imitation, though experience- dependent, adapts action to perception with great plasticity. For Lepage and Théoret (2007), this plasticity renders plausible the hypothesis of a

gradual development of the Mirror neuron System (MNS) through repeated motor activity and related sensory feed-backs of the foetus. Similarly, the adult MNS is experience-dependent and plastic: our mirror neurons resonate to the observation of actions that are not part of our motor repertoire only after repeated exposure (Calvo-Merino et al., 2005). This demonstration of a flexible repertoire is of paramount importance. Indeed the individual deprived of social encounters would not have the opportunity to enrich their repertoire according to the observed actions of the others. It is the beginning of a perception-action coupling that will take many different forms, from acts to thoughts, but will never stop. A few months later, having enriched their motor repertoire thanks to their matching of others' actions, toddlers will start being able to store representations of actions they have never done: How? The storage originates from somatotopic and proprioceptive recalls of past experience (Raos, Evangeliou & Savaki, 2007) involving elements of the observed actions. This mental recombination is a powerful multiplier of experiences as it prints in our memory of actions those actions performed by others that we have observed but never done. This is possible, proviso we have elements of the observed action in our repertoire. Then we can build new possibilities with old ones -a basic illustration of Epstein (1996)'s theory which asserts that new ideas result from interconnections among old ones. Notice that though this novel repertoire is built thanks to the actions of the others, it is different from the others' repertoire just because it is issued from our own history of actions, and our own gestural procedures. From acts to thoughts, the process is similar, as shown by Fadiga's team (Fadiga, Craighero & D'Ausilio, 2009). The benefit of innovation is individual here at first but through the process of interactive imitation, it will be revisited as a common and innovative by-product of the interaction.

6 Imitation and Social Neuroscience

Inspired by our developmental research, we have built an innovative fMRI platform which allows synchronizing behavioural and brain recordings during online imitative interaction. Our results replicated previous findings demonstrating the existence of an imitative neural network (Iacoboni et al., 1999), and most importantly revealed the involvement of the dorsolateral prefrontal cortex and other regions involved in social anticipation and adjustment, thus verifying that reciprocal imitation is a prototype of two-person coregulation (Guionnet, Nadel, Bertasi, Delaveau, Sperduti, & Fossati, 2011). Our fMRI work thus supported the notion that imitation is a useful model for two-person neuroscience.

Two-person neuroscience aimed at investigating the simultaneous activity of two brains recorded simultaneously during a dyadic encounter. The novel technique known as 'hyperscanning' allows for simultaneous recording (through fMRI or EEG) of brain activity in multiple participants, facilitating both within- and between-brain analyses. We used hyperscanning in a dyadic context of free interaction and it was the first experiment of this kind, to our own knowledge. The dyads were composed of two unacquainted subjects seated in separate experimental cabins and viewing each other's hand gestures. Dyads engaged in imitation (i.e., made hand gestures of similar

morphology) roughly about 65% of the time and synchronized hand movements (i.e., gestures began and ended at the same time, but did not necessarily share the same morphology) about 78% of the time. Within each dyad, we observed a spontaneous emergence of a balanced turn taking between the role of model and imitator; EEG data showed emergent synchronization of brainwaves in subjects who were engaged in spontaneous imitation with interactional synchrony (Dumas, Nadel, Soussignan, Martinerie & Garnero, 2010). This inter-brain relationship was strongly present in the alpha-mu frequency band where it symmetrically linked the right parietal regions of the two subjects (Figure 5B). Inter-brain synchronization of right parietal regions in this range of rhythmic activity suggests a link between inter-individual coordination and the intra-individual temporal estimation and anticipation necessary for an effective alternation of roles (Wilson and Wilson, 2005). Interbrain synchronization was also observed in higher frequency bands, though not between homologous brain regions according to the role of imitator or model. (Dumas, Martinerie, Soussignan & Nadel, 2012).

Besides an understanding of the other's action, turn-taking requires anticipation of other's intention and active co-regulation of complementary action on the part of the two partners. Our PsychoPhysical Interaction results suggest that these sophisticated aspects of an ongoing social interaction involve both the mirror and the mentalizing systems (Sperduti, Guionnet, Delaveau, Fossati & Nadel, 2014). The mirror system allows understand and anticipate action schemes leading to synchronized actions and the mentalizing system accounts for the novelty emerging from the imitative interaction.

7 Conclusion

Cognition involving others, or social cognition, is often conceptualized as the solitary third person computation of mental states. Relatively little attention has been paid to how individuals use their cognitive capacities at the behavioral and brain levels in social exchanges. We introduced imitation as a valuable model of dynamic social interactive phenomenon, and described laboratory procedures for studying it in behavioral and neuroimaging contexts. From birth on, imitation allows us to continuously revisit our resources thanks to the observation of others. Interacting with others multiplies the effect of observation. Indeed it generates novelty emerging from the dynamic coregulation of two different repertoires that couple perception and action and anticipate each other's responses.

We reviewed research that reveals behavioural and neural synchronization of individuals engaged in imitation. In the latter case, brain activity is correlated in imitative partners but the pattern expressed by an individual depends on the individual's role (i.e., model or imitator). We linked these findings to theoretical notions about mirroring and mentalizing brain systems, and then described how mirroring and mentalizing support the notion of generative cognition, even in basic forms of communication such as reciprocal imitation. And finally we showed that the traditional view of imitation does not take into account the exceptional potential of generativity that it allows.

References

- Andry, P., Gaussier, P., Moga, S., Banquet, J.P., Nadel, J.: Learning and communication in imitation: an autonomous robot perspective. *IEEE Transactions on Systems, Man and Cybernetics* 31, 431–444 (2001)
- Calvo-Merino, B., Glaser, D.E., Grèzes, J., Passingham, R.E., Haggard, P.: Action observation and acquired motor skills: an fMRI study with expert dancers. *Cerebral Cortex* 15, 1243–1249 (2005)
- Chomsky, N.: *Aspects of the theory of syntax*. MIT Press, Cambridge (1965)
- Dennett, D.C.: Intentional systems. *Journal of Philosophy* 68, 87–106 (1971)
- De Jaegher, H., Di Paolo, E.: Enactivism is not interactionism. *Frontiers in Human Neuroscience* 6 (2012), doi:10.3389/fnhum.00128
- Di Paolo, E., De Jaegher, H.: The interactive brain hypothesis. *Frontiers in Human Neuroscience* 6 (2012), doi:10.3389/fnhum.2012.00128
- Dumas, G., Nadel, J., Soussignan, R., Martinerie, J., Garnero, L.: Interbrain synchronization during social interaction. *PlosOne* 5, e12166 (2010)
- Dumas, G., Martinerie, J., Soussignan, R., Nadel, J.: Does the brain know who is at the origin of what in an imitative interaction? *Frontiers in Human Neuroscience* 6 (2012), doi:10.3389/fnhum.2012.00128
- Epstein, R.: *Cognition, Creativity, and Behavior: Selected Essays*. Praeger, München (1996)
- Fadiga, L., Craighero, L., D’Audilio, A.: Broca’s area in language, action and music. *Ann. N.Y. Acad. Sci.* 119, 448–458 (2009)
- Fogel, A.: Two principles of communication: Co-regulation and framing. In: Nadel, J., Camaioni, L. (eds.) *New Perspectives in Communicative Development*, pp. 9–22
- Girard, R.: *Things hidden since the foundation of the world* (1987). Stanford University Press, Stanford (2005) (French edition: 1978)
- Guionnet, S., Nadel, J., Bertasi, E., Sperduti, M., Delaveau, P., Fossati, P.: Reciprocal imitation: toward a neural basis of social interaction. *Cerebral Cortex* 22(4), 971–978 (2012)
- Iacoboni, M., Woods, R.P., Brass, M., Bekkering, H., Mazziota, J., Rizzolatti, G.: Cortical mechanisms of human imitation. *Science* 286, 2526–2528 (1999)
- Lepage, J.F., Théoret, H.: The mirror neuron system: grasping others’ actions from birth? *Developmental Science* 10, 513–523 (2007)
- Meltzoff, A.N., Moore, M.: Newborn infants imitate adult facial gestures. *Child Development* 54, 702–709 (1983)
- Nadel, J., Butterworth, G.: *Imitation in infancy*. Cambridge University Press, Cambridge (1999)
- Nadel, J., Camaioni, L.: *New perspectives in communicative development*. Routledge, London (1993)
- Piaget, J.: *Play, dreams and imitation in childhood*. Norton (translated from: *La formation du symbole chez l’enfant*), New York (1945/1962)
- Piontelli, A.: *Development of normal fetal movements*. Springer, Milano (2010)
- Prepin, K., Revel, A.: Human-machine interaction as a model of machine-machine interaction: how to make machines interact as humans do. *Advanced Robotics* 21, 1709–1723 (2007)
- Raos, V., Evangelidou, M.N., Savaki, H.E.: Mental simulation of action in the service of action perception. *Journal of Neuroscience* 27, 12675–12683 (2007)
- Soussignan, R., Courtial, A., Canet, P., Danon-Apter, G., Nadel, J.: Human newborns match tongue protrusion of disembodied human and robotic mouths. *Developmental Science* (2010), doi:10.1111/j.1467-7687.2010.00984

- Sperduti, M., Guionnet, S., Fossati, P., Nadel, J.: Mirror Neuron System and Mentalizing System connect during online social interaction. *Cognitive Processing* (2014)
- Stern, D.: *The first relationship: infant and mother*. Harvard University Press, Harvard (1977)
- Trevarthen, C.: Descriptive analyses of infant communicative behaviour. In: Schaffer, H.R. (ed.) *Studies of Infant-Mother Interaction. The Loch Lomond Symposium*, pp. 227–270. Academic Press, London (1977)
- Varela, F.J., Thompson, E.T., Rosch, E.: *The embodied mind: Cognitive science and human experience*. MIT Press, Cambridge (1991)
- Vernant, J.-P.: *Myth and thought among the Greeks*. Routledge & Kegan Paul, London (1983)
- Wilson, M., Wilson, T.: An oscillator model of the timing of turn-taking. *Psychon. Bull. Rev.* 12, 957–968 (2005)
- Zittrain, J.: *The future of the internet and how to stop it*. Yale University Press, Yale (2008)