Bidirectional Influences of Emotion and Action in Evaluation of Emotionally-Connoted Words

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The goal of this review is to present the embodied character of emotionally-connoted language through the study of the mutual influences of affective language and motor action. After a brief definition of the embodied approach of cognition, the activity of language understanding is presented as an off-line embodied process implying sensory-motor resonance. Then the bidirectional character of influences between language and action will be addressed in both behavioral and neuropsychological studies, illustrated by the specific case of emotionally-connoted language. These reciprocal effects are grounded on the motor correspondence between action and the motor dimension of language, emerging from a diversity of source such as adaptive motivation, past experiences, body specificities, or motor fluency.

Keywords: action; bidirectional influences; embodied cognition; emotion; motor fluency

1. Introduction

The evolution during the 20th century of the concept of cognition and of the relationship between the individual and his environment has led most recent approaches in this area to ask the question of the incarnation of cognition. Indeed, the body appears as the first media of interaction with the environment, in the sense that it influences and constrains the cognitive processes: An object, a situation, only makes sense because it implies a number of actions for the cognitive subject. Cognition, therefore, cannot be considered as an independent entity, divorced from its context or from its surroundings, either it is internal (non-cognitive process, motricity, bodily states) or external (places, situations, events, etc.). Instead, human cognition can only be considered as the coordination of cognitive and non-cognitive processes, in a situated and integrated way (Barsalou 2008). By replacing the cognitive activity in context, the involvement of the body as a medium of the self/environment link emerged as crucial to the study and understanding of cognition.

If reading and understanding activities are based on embodied processes,

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then the emotional content of language must also be embodied in order to be understood. Furthermore, the emergence of a new conception of emotion (with ancient roots in philosophy: William James 1894) defined as the consequence of bodily phenomena contribute to address the question of the embodiment of emotional language. In this article, our goal is to present the embodied character of emotionally-connoted language, and the mutual influences between affective language and motor action. The first section is focused on a brief definition of the embodied approach of cognition. We define the mechanisms linked to the incarnation of mental processes, and present language as an off-line embodied activity, therefore implying specific motor resonance. In the second section, we address the question of the bidirectionality of the influences between language understanding and action. Behavioral and neuropsychological studies support these mutual effects. Finally, the third section extends the bidirectional influences to the study of emotionally-connoted language, linked to motivational and non-motivational movements. The compatibility effects between affective language and motor activity are discussed in terms of motor fluency, as a novel and encouraging explanation for the matching of emotion and action.

2. Embodiment in Cognition and Language

Sensory-motor processes used to simply be considered by classic theories of cognition as input or output to cognitive systems. Nowadays, those processes are entirely integrated in recent approaches of mental functioning, known as embodied theories of cognition. Those conceptions are funded on a rejection of the segregation between high- and low-level mental processes, and generally consider mental activity in a unifying perspective. One major contribution of embodied approaches is the redefinition of memory as a memory of processes and no longer a memory of content. According to this view, the main function of memory is to mediate the interaction with the world, by matching current activity and traces left by previous experiences (Glenberg 1997). Barsalou (2008) defined this phenomenon as the "re-enactment of perceptual, motor and introspective states acquired during the interaction with the environment, the body and the mind" (p. 618). Concretely, the interaction with an object, either directly (via perception) or indirectly (via thought or imagination) consists in the mental simulation of the multimodal states linked to brain systems allocated to perception and action that were running during precedent interactions (Barsalou 1999).

Perceptual and motor processes are central in this approach, to such an extent that some theories propose a similarity of nature between perception and action: Theory of Event Coding (Hommel *et al.* 2001; Hommel 2004), Mirror Neuron System theory (Rizzolatti *et al.* 1996; Gallese *et al.* 1996; Gallese 2008). According to these approaches, the same kind of representations is used to match motor and perceptual states, explaining the resonance between perception and motor planning or execution in situation of simulation (Bach *et al.* 2010). Mental simulation, defined as the re-enactment of sensori-motor states usually linked to an object when interacting with it, can be explained in terms of an automatic and direct link between perception and action (*affordances*; Gibson 1979; Tucker &

Ellis 1998), or in terms of motor resonance.

According to various authors (Zwaan 2004, 2009; Buccino *et al.* 2005), observation and simulation of action are based on the individual own motor repertory. When observing or imagining an action that one is able to perform, motor areas in the brain are activated as if one was actually executing it (Gallese 2008), which is called motor resonance. On the other hand, when the activity is not in the individual repertoire (such as a technical dance movement, or a movement done by an animal), there is no motor resonance in the brain, because the body has no traces of such a movement.

We focused until here on simulation and resonance in situations with the object of mental activity being present, and available from direct perception, that is to say in on-line situations. However, embodied theory of cognition extends those processes to off-line situations, namely cases where the object of mental activity is absent, not available from direct perception (Niedenthal *et al.* 2005).

Language is a key example of off-line cognition: By this means, people make reference to objects that are absent from their environment, so they are able to interact with it via linguistic production and understanding. As for perception or visual imagination of action, language understanding is defined as a sensory-motor activation functioning by the generation of motor resonance between the linguistic content and the experiential repertoire of the individual (Barsalou 1999; Gibbs 2003; Zwaan 2004, 2009; for a review on the role of motor processes on language understanding, see Willems & Hagoort 2007; Fisher & Zwaan 2008; Gallese 2008). Glenberg & Robertson (1999) describe three stages in language understanding: Firstly language content is matched with the referred object, then the cognitive system simulates the action possibilities implied by this object, and finally a coherent action pattern is created, which leads to understanding. Different actions can be involved in those simulations: simulation of the action of communication (lips and tongue movements, i.e. articulatory system) and simulation of language content (for examples and reviews see Galantucci *et al.* 2006; Willems & Hagoort 2007; Gallese 2008). In this section and the followings, we will focus on the second type of motor resonance: language content simulation.

Concerning language content, if simulation theory clearly explains the embodiment of concrete language, the question of the embodiment of abstract language has been raised (for a review, see Pecher *et al.* 2011). One major account in favor of the embodiment of abstract language is based on the notion of linguistic metaphor (Lakoff & Johnson 1980, 1999; Gibbs 2003; Meier & Robinson 2004). Conceptualization of abstract notion is supposed to process by analogy, with a generalization of action patterns initially associated to a more concrete concept. For example, an abstract concept such as time is frequently associated to the more concrete concept of space, leading to a conception of time as a spatial dimension. Past is figured by the space behind oneself, and future is represented by the space in front of oneself (Boroditsky 2000).

Since language is considered as an embodied activity, no one should be surprised of the ties between language and action, and of the influence that these processes have on each other.

3. Bidirectional Influence of Language and Action

The study of language and action and of the mutual effects between them has inspired many researches, both in behavioral and neuropsychological approaches. This presentation concerns minimal linguistic units (isolated words) as well than sentences processing (however, see Willems & Hagoort 2007; Fisher & Zwaan 2008; Gallese 2008 for reviews). Moreover, the term action is used here to describe both action planning, activation of motor areas in the brain or actual execution of movements.

3.1. Effect of Language Understanding on Action

One of the first works which can be interpreted with an embodied approach of language is the study published by Bargh *et al.* (1996). The authors demonstrated that the exposition to words relative to the elderly (but with no explicit mention of this common point) have made the participants' walk slower, with their back bent, in a way reminding the way old people moves.

This study is an example of what has been called the Action Compatibility Effect (ACE; Glenberg & Kaschak 2002). This effect shows that perceive linguistic content relative to a specific action leads to behave in a way congruent with this action. When reading a sentence such as "Andy delivers the pizza to you", the realization of a congruent movement (hand moving toward the body) is easier than an opposite movement (hand moving away from the body). This compatibility effect also manifests itself with more abstract sentences like "Liz told you the story", where the notion of transfer is less evident. Many studies have been inspired by the ACE. Some works have demonstrated an effect of words on the planning of action (Gentilucci *et al.* 2000; Tucker & Ellis 2004), others have shown a facilitation effect for the activity of specific effectors when reading sentences describing movements of the same effectors (Scorolli & Borghi 2007; Borghi & Scorolli 2009). Furthermore, it has been demonstrated that the mere description of a specific concept activates the realization of ocular movements used to interact with it in everyday life (e.g., look up when hearing about a building, look down when hearing about a canyon, Spivey *et al.* 2000). Finally, studies in our laboratory have shown that even verbal responses considered disembodied as "yes" and "no" have a motor component, manifesting specific associations with movements of response (Brouillet *et al.* 2010). In the neuropsychological field, the study of premotor and motor areas of the brain has shown specific activation depending on the linguistic content. Various studies using imagery techniques such as functional MRI have demonstrated that reading action words associated to specific effectors (e.g., *pick*/*lick*/*kick*; Hauk *et al.* 2004) led to a somatotopic activation of motor and premotor areas in the brain (see also Buccino *et al.* 2005; Pulvermüller *et al.* 2005b; Tettamanti *et al.* 2005; for a review, see Jirak *et al.* 2010).

Both the behavioral and neuropsychological data support the idea of an influence of language processing on the planning and the realization of action. But if a motor resonance can occur between the motor component activated by language understanding, and actual motor execution, embodied theories of

cognition predict that the reverse association is also possible. The next section considers the influence of motor activity on the comprehension of language.

3.2. Effect of Action on Language Understanding

Few researches have focused on this reverse link between action and language. Nevertheless, this question is of importance to validate the simulation account of language understanding. Indeed, one major critic against the simulation approach of language comprehension is that the motor activation linked to language only occurs after comprehension, and is not a part of the processing of linguistic content (Mahon & Caramazza 2008). One way to answer to this critic is to show that a simple motor activation is sufficient to enhance language understanding. If action facilitates comprehension, it would validate the idea of a critical motor activation in language understanding (Rueschemeyer *et al.* 2010). Some experimental works indeed demonstrate an effect of action on action language comprehension.

In 1989, Klatzky *et al.* had already shown that the presentation of manual postures primed the comprehension of word pairs describing a congruent action. More recently, Lindemann *et al.* (2006) demonstrated that action preparation (e.g. "drink from a cup") activates the semantic dimension linked to the goal of the movement prepared. This semantic activation functions as a prime and facilitates the performance in a subsequent lexical decision task (e.g., "Is *mouth* a word?"). Helbig *et al.* (2006) have shown a priming effect in a denomination task, when succeeding pictures consisted in objects usually used in the same way (e.g., nut-cracker and pliers; see Myung *et al.* 2006 for similar results using words related to the same actions). But one critic to this kind of studies is that the effect observed is more a visual effect than a motor one: It can be the perceptual similarities between primes and targets that allow facilitation. To reject this point, Rueschemeyer *et al.* (2010) designed a study in which words were primed by an actual motor execution, with no linguistic or visual input: Participants had to judge if words denoted functionally manipulable objects or not, while realizing an intentional movement, a passive movement or no movement at all. Results showed that participants were faster to recognize words denoting manipulable objects when they were engaged in an intentional action rather than in a passive action, or no action. This study illustrates that the activation of the neural motor system facilitates the processing of words with a motor component.

Various neuropsychological studies also support the effect of action on language understanding (for reviews see Willems & Hagoort 2007; Borghi & Pecher 2011). In particular, one criticism made to an embodied approach of language understanding was to consider that the motor activations observed in cortex and pre-cortex were nothing but by-product of activations linked to imagery of language content. Pulvermüller *et al.* (2005a) argued against this claim, showing with magnetoencephalography (MEG) that activity in the primary motor cortex linked to leg activity occurs 150 ms after the onset of action-word describing leg movements. This very early activation in the comprehension process rules out the exclusion of motor areas in language understanding.

All these works are in favor of a bidirectional link between action and language, thanks to the mutual activation of the motor component of both linguistic content, and of planned or executed movement. We will now address the question of a particular type of language that is emotionally-connoted language, and its bidirectional links with action.

4. The Case for Emotion

4.1. An Alternative Definition of Emotion

A classical conception of emotion, in accordance with common sense, would define emotion as an evaluative cognitive mechanism caused by the confrontation with an emotionally-connoted object, and responsible for bodily modifications at an internal (e.g., cardiac rhythm) or external level (e.g., approach behavior). For example, when one perceives an object evoking fear (e.g., a spider, a snake), this perception activates the emotion of fear, which implies bodily symptoms like shaking, sweating, escape reflex, etc.

But in the late nineteenth century, American philosopher William James has proposed an alternative definition of emotion, inversing this conception: Emotion might be the very consequence of the bodily changes. In a communication from 1884, James explains that bodily changes follow directly the perception of the exciting fact. Concretely, emotion is the feeling of these changes. According to this conception, if during the emotional experience, everything physical is taken back, there is nothing left of the emotion. In summary, there is no such thing as a disembodied emotion. Consequently, the simple fact of voluntarily activate bodily symptoms might be sufficient to create the emotion.

Contemporary authors have integrated this conception of emotion, and agree on the idea that comprehension of emotionally-connoted language needs at least a partial simulation of the same neuronal and bodily mechanism than actual emotional experience (Glenberg *et al.* 2005; Havas *et al.* 2007; Winkielman *et al.* 2008). The point is that bodily expression and interpretation of emotion share a reciprocal relation (Niedenthal 2007), such as when the body is already in a state linked to emotion, there is a facilitation to feel the same emotion. Various manipulations of emotional expressions have been used to illustrate this effect (see section 4.3.1. for a detailed presentation). Conversely, understanding emotionally-connoted language implies the simulation of the bodily state associated. Vermeulen *et al.* (2007) have demonstrated a switching cost in a property verification task: Participants were faster to recover the affective dimension of concepts after a trial into which they had to simulate an emotional feature rather than a sensorial one (e.g., visual, auditory, etc). This result indicates that to access the emotional dimension of concepts, a simulation of the state associated to this emotion is necessary, and that this simulation enters more easily in resonance with another affective simulation than with a sensorial one. This effect supports the idea of the necessity of an embodied activation to understand affective concepts.

This approach of emotion has since been illustrated by an increasing amount of studies, confronting emotionally-connoted language and various bodily behaviors, either directly or indirectly associated to emotion.

4.2. Emotionally-Connoted Language and Motivational Movements

In accordance with the conception presented in the precedent section, the role of emotion can be defined as a signal to indicate to the organism the presence of a relevant element in the environment, in terms of its potential consequences. The emotion is therefore the result of an evaluation concluding that the presence of either a negative element represents a danger or a positive one represents a potential benefit (Neumann *et al.* 2003). This evaluation has to be related to an important function of cognition which is motivation: Once the situation has been defined as positive or negative, the organism has to plan his behavior, to be as adapted as possible (Lang *et al.* 1990). Depending on the evaluation, two kinds of motivation might arise. Elliot (2006: 112) explains:

> Positively evaluated stimuli are inherently associated with an approach orientation to bring or keep the stimuli close to the organism (literally or figuratively), whereas negatively evaluated stimuli are inherently associated with an avoidance orientation to push or keep the stimuli away from the organism (literally or figuratively).

The mutual influence of emotional processes and approach and avoidance behaviors has inspired many works since the 1990's (Cacioppo *et al.* 1993; Förster & Strack 1997; Chen & Bargh 1999; Neumann & Strack 2000; Freina *et al.* 2009; Brouillet *et al.* 2010). One methodology to study those associations proposes to use arm flexion/extension movements as approach and avoidance behaviors. Cacioppo *et al.* (1993), with neutral items (unknown Chinese ideographs), and Neumann & Strack (2000) with emotionally connoted items, showed that flexion (approach behavior) allowed more positive evaluations than extension (avoidance behavior), while the extension elicited more negative responses than flexion. These works therefore illustrate the influence of motor actions of approach/avoidance on the evaluation of objects. With another procedure, Chen & Bargh (1999) demonstrated the reverse effect (i.e. the influence of emotional processes on motivational behaviors), showing that the perception of emotional words allows faster movements of response (push or pull a lever) when it corresponds to the enabled motivation (approach/pulling for the positive words, and avoidance/pushing for the negative words) than when this movement is contrary to the motor program activated. This effect of emotionally-connoted language on action has to be distinguished from pure ACE. The Action Compatibility Effect (Glenberg & Kaschak 2002) results from a direct motor resonance between the language content (either concrete or abstract) and the action planified or realized. Concerning emotional linguistic items, the matching between the stimuli and the actions is not direct, but is due to the conjunction of in one hand, the adaptive associations between emotion and motivational behaviors, and in the other hand the actual realization of such movements.

Other authors have pointed out the contextual nature of approach and avoidance behaviors: If approach consists in reducing the distance between

oneself and an object, one can either move closer to the object, or move the object closer to oneself. Similarly, to avoid an object, one can move away from it, but can also push it. Freina *et al.* (2009) showed that Chen & Bargh's results (1999), obtained when subjects had a lever in the hand, could be reversed when their hands were empty. It appears that when individuals take the lever, they act as if this object was the emotional item and therefore push it when it is negative, and pull it when it is positive. On the contrary, when the hand is empty, it approaches positive items on the screen, and get away from the negative items. Similarly, Cretenet & Dru (2004, 2008; see also Dru & Cretenet 2005) specified the conclusions of Cacioppo *et al.* (1993) by distinguishing the responses from the left or right arm. Movements compatible with positive words (i.e. allowing the most positive evaluations) are not simply flexion ones, but right arm flexion and/or left arm extension. By contrast, negative words are compatible with the flexion of the left arm or the extension of the right arm ("motor congruence effect"; Cretenet & Dru 2004, 2008; Dru & Cretenet 2005, 2008). The significance, the context and the laterality of the movement are essential for the study of associations between emotionally-connoted and motivational behaviors.

To summarize, all these studies are in accordance with the idea of a bidirectional nature of the links between affective language and motivational behaviors (Neumann & Strack 2000; Neumann *et al.* 2003; Centerbar & Clore 2006).

4.3. Compatibility between Emotionally-Connoted Language and Other Kinds of Action

4.3.1. A Diversity of Bodily Expressions

All the works presented previously are based on a total motor resonance between the movement orientations evoked by the linguistic material and the actual responses executed by the participants: All the behaviors considered in these studies are standard approach and avoidance behaviors. But a wide range of motor behaviors were found to match with the motor component of emotionally-connoted language.

One famous paradigm was conceived by Strack *et al.* (1988), and transferred to the study of language by Glenberg *et al.* (2005) and Havas *et al.* (2007). This manipulation provokes or inhibits smile because the participant has to hold a pen either between his teeth (provoking a muscular activation close to a smile), or between his lips (implying a muscular activation incompatible with a smile). While holding the pen, participants had to evaluate emotionally-connoted sentences. Results showed a compatibility effect such as smiling enhanced the positive evaluation of positive sentences, while pout implied a more negative evaluation of negative sentences.

Compatibility effects between emotional expressions and the understanding of emotionally-connoted language were also studied with the use of head movements. Head movements are, at least in occidental cultures, strongly associated with intention to agree or refuse. Wells & Petty (1980) have first used these bodily manipulations to study effect of emotion expression on attitudes. In this study, participants had to express their degree of agreement with school

reforms. They were listening to an auditory message explaining this reform, and while listening, they had to move their head either horizontally or vertically, under the cover story of judging the quality of headphones. Results showed that participants who had shaken their head vertically were more convinced by the message than the ones who had shaken their head horizontally. The authors interpreted this effect as an influence of the expression of agreement on the formation of a positive attitude. In a same way, and with linguistic content, ask participants to nod either as if they were agreeing or refusing something during the presentation of emotionally-connoted words allowed a better restitution of the words presented in a compatible condition, namely agreeing in front of positive words, and refusing in front of negative words (Förster & Strack 1996).

These researches demonstrate that the context of a specific movement is sufficient to transfer its affective component to the evaluation of object such as linguistic stimuli.

4.3.2. Emotionally-Connoted Language and Lateral Movements

Recent works have shown that even movements apparently unrelated to motivation or emotion could be associated to valence. The question of laterality was raised in the study of embodied language, with the work of Cretenet and Dru (2004, 2008; Dru & Cretenet 2005, 2008) which has introduced the question of the hand used in approach/avoidance compatibility effect (see section 4.2. above), but also in neurological studies. Willems *et al.* (2010) have shown that verbs describing manual and non-manual actions led to different brain activation, with manual action-verbs implying an activation of the premotor cortex, dependant of the manual dominance of the participants (left premotor cortex for right-handers, and right premotor cortex for left-handers).

In the specific field of emotion, Casasanto (2009) showed that when subjects were asked to place two items (one positive and one negative) in two separate areas situated on the left and the right part of space, they tended to relate the positive one to the side of their dominant hand, and the negative one to the other side. The author interprets this effect with the "body-specificity hypothesis": Subjects with different bodies and who use it in a different way (right-handers and left-handers) conceive the world differently. Similar to the precisions made to the studies made by Cacioppo *et al.* (1993) or Chen & Bargh (1999), these associations might be dependent on the action of the subject. Casasanto & Chrysikou (2011) asked their right-handed participants to first perform a motor task, by manipulating little objects with their two hands, while their right-hand was disabled by wearing a bulky ski glove. This manipulation was designed to make them feel and act as left-handers. The second task was the same than in Casasanto (2009), and showed that momentarily disabling the right-hand made right-handers manifest the same valence/laterality effect than left-handers, namely to associate positive to the left, and negative to the right. It indicates that associations related to dominant preference can be reversed by short-term changes in individual behavior. Similarly, work in our laboratory showed that right-handers acting as left-handers in a valence judgment task expressed the same compatibility effects between left and positive than left-handers (Milhau *et*

al. 2012). Precisely, participants had to judge the valence of positive and negative word by pressing two keys with respectively a rightward and leftward arm movement (the matching valence/laterality was counterbalanced). They were all right-handed but had to use either their right or their left hand to answer. Results showed that when using their dominant hand, right-handers manifested the associations exposed by Casasanto (2009): They were faster to recognize the positive word when pressing the right key than the left key. But the main result is that when using their left hand to answer, right-handed participants seems to become real left-handers, since they were faster in judging positive word when answering with a leftward movement than with a rightward action. However, this effect was limited to positive stimuli and did not extend to negative words (an interpretation of this result is proposed in the next section).

4.3.3. Motor Fluency as an Explicative Approach of Compatibility Effects

When the compatibility effect between motion perception and expression is not based on the similarity of action orientation (i.e. approach/avoidance behaviors), another kind of processes must be responsible of this matching phenomenon. One interpretation, proposed by Casasanto (2009), is that the tendency to associate positive concept to the side of the dominant hand was due to the fact that participants interact with the world more frequently with this hand, and are therefore more efficient (both faster and more accurate) when executing actions on the corresponding side. Another explanation, purely biomechanical, can be invoked to explain those effects. The majority of studies about the associations between emotionally-connoted language and non-emotional movements, like lateral movements, implied the activity of the arms. Anatomical data informs us that arm movements executed across the body (adduction, e.g., right arm directed to the left) are much more costly in terms of energy than movements to the same side (abduction, Laude *et al.* 1978).

Both of these propositions focus on the dimension of facility of one movement over another one: Recent studies have advanced the notion of "motor fluency" to qualify the ease linked to the realization of specific movements, due either to habit or to a low energy cost (Beilock & Holt 2007; Casasanto & Chrysikou 2011). This concept refers to a definition of fluency as an indicator of the continuous and effortless flow by which a process is realized (Alter & Oppenheimer 2009). This experience of fluency seems to emerge of a comparison, a shift between the cost initially anticipated to realize an activity, and the cost of the actual execution of this activity. Therefore, and in accordance with ideomotor theories of cognition (Hommel *et al.* 2001), motor fluency implies that action is conceived in terms of its perceptual consequences.

In addition, analogous to the fact that perceptual (Reber *et al.* 1998; Winkielman *et al.* 2002) or conceptual fluency (Whittlesea 1993, Experiment 5) are emotionally marked, motor fluency seems to be associated with a positive emotional tagging. Since we consider fluency as monitoring the quality of one's own functioning, this positive marking would thus act as a reward system, a positive reinforcement for a successful motor activity (Winkielman & Cacioppo 2001; Cannon *et al.* 2010; Brouillet *et al.* 2011). This positive marking might be

responsible for the fact that motor fluency impacts specifically positive stimuli (Milhau *et al.* 2012, see also Brouillet *et al.* 2010). The fluent movements implied a positive feeling that entered in resonance with the emotional dimension of the positive stimuli, allowing the compatibility effect highlighted in this study. Congruent with this positive marking of motor fluency, we ran in our laboratory an experiment demonstrating that the emotional dimension linked to lateral fluent movements could be sufficient to allow an emotional evaluation of neutral linguistic stimuli. The participants' task was first to execute a lateral arm movement in response to a visual signal while reading a neutral word. Then they had to evaluate the valence of the word on a scale. All the participants were right-handers and used their right hand to respond. Our results demonstrated that words judged after a rightward movement were evaluated as more positive than after a leftward movement. The motor fluency of an arm movement directed to the dominant side for the participants led them to project the positive marking of this movement onto the evaluation of neutral words (Milhau *et al.* 2012). Conversely, the absence of fluency has never been associated to negativity (Winkielman & Cacioppo 2001; Brouillet *et al.* 2011), probably because it does not question the quality of the system's functioning, and therefore it does not need any negative reinforcement in order to adapt a behavior.

To summarize, compatibility effects between non-motivational behaviors and emotionally-connoted stimuli do not exist *per se*, but depend on the context of the movement and its energy cost, namely its motor fluency.

5. Conclusion

Our goal in this article was to emphasize the bidirectional nature of the links between emotion and action, in the particular field of language understanding.

The works reviewed here lead us to two main conclusions. First, the processing of emotionally-connoted words acts as an external signal for the cognitive system that enables the compatible behavior. Subsequently to the presentation of affective language, the realization of a compatible motor response is facilitated, either in terms of motivation with approach and avoidance behaviors, or in terms of motor fluency with lateral movements. Secondly, action (understood as either action planning, motor and pre-motor cortex activation or actual motor execution) can influence the understanding of emotionally-connoted language, or even provide an emotional connotation to initially neutral linguistic material, thanks to the positive marking of motor fluency.

Both of these findings resonate with William James' (1884) claim: Emotion is not a cause but a consequence of cognitive activity. This emotional experience emerges from the successful matching (or not) between a cognitive activity, and the signification assigned to it. In the specific field of emotionally-connoted language, this matching occurs because of the resonance between a motor process, and the motor dimension of language. The wide variety of researches demonstrates that the motor correspondence between these elements can come from a diversity of sources, such as adaptive motivation, past experiences, body specificities or fluency.

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