Accepted on **Brain and Cognition**, April 2020.

Special issue on Functional links between language and motor activity,

Edited by Victor Frak, Henry Cohen

Different kinds of embodied language: a comparison between Italian and
Persian languages

Mina Ghandhari^{1*}, Chiara Fini^{2*}, Federico Da Rold³, Anna M. Borghi^{2,3}

1. Alzahra University, Tehran

2. Sapienza University of Rome, Department of Dynamic and
Clinical Psychology

3. Institute of Cognitive Sciences and Technologies, National
Research Council of Italy, Rome

*Shared first authorship

Corresponding authors: Chiara Fini, *email address:* chiara.fini@uniroma1.it; Anna M.
Borghi, *email address:* anna.borghi@uniroma1.it; *address:* Via degli Apuli 1, 00185, Roma.

Abstract

It is debated whether only concrete but also abstract, figurative sentences, e.g.: “She grasps the cup” vs. “She grasps the concept”, are grounded in the sensorimotor system. Importantly, studies on sentences with action verbs and motor system activation have been conducted so far only with WEIRD samples (Western cultures, in North American and European countries). The aim of our work is to investigate the relationship between language and motor responses using both concrete and abstract sentences in Italian and Persian languages. In the present study, Italian and Persian participants were asked to read the sentences on the screen. The sentences referred either literally or metaphorically to motor actions. They were accompanied by a video displaying a movement that could be congruent or incongruent with the one described in the sentence. Participants were asked to re-execute the movement observed and subsequently they had to perform the task evaluating whether the sentence made sense or not. In the Italian sample a strong effect of concreteness was present, especially in the congruent but also in the incongruent condition. In the Persian sample, instead, there was an inhibition effect of congruent trials, particularly with concrete sentences, and in the incongruent trials no difference in RTs between abstract and concrete sentences was present. Results indicate that cross-cultural differences have to be taken into account when investigating the relationship between language and action.

Keywords: WEIRD, action, sentences, cultures, language grounding, embodied cognition

Highlights:

- Culture modulates the cross-talk between language and action
- In the Persian sample, when an action observed and performed is compatible with the action expressed in a sentence induces an inhibition of the motor response in a sentence sensibility task, especially when the sentence is concrete.
- In the Italian sample abstract sentences are processed faster than concrete ones (concreteness effect)
- In the Italian sample (WEIRD), when an action observed and performed is compatible with the action expressed in a concrete sentence it induces a tendency towards the facilitation of the motor response in a sentence sensibility task

1. Introduction

Do people of different cultures comprehend action related language in a different way?

The fact that action words and sentences recruit sensorimotor information is quite an established finding. Many consolidated research lines address this issue. Here we will focus on three of them, i.e. the studies on the relationship between action verbs and involvement of effectors, the studies on the Action Sentence Compatibility (ACE) effect, and the studies on the spatial interference effect. Importantly, most studies within these research lines were conducted with Western participants. We will now briefly describe these research lines, and propose a study in which action-language integration is investigated with a cross-cultural approach.

1.1 Action verbs and effectors. When we process action verbs and sentences entailing action verbs, we implicitly activate the effector to which the words refer. Seminal EEG and fMRI studies have demonstrated that different areas of the brain are activated when reading verbs referring to different effectors, such as ‘kick’, ‘lick’, ‘pick’ (Hauk, Johnsrude, & Pulvermüller, 2004; Pulvermüller, Härle, & Hummel, 2001; Tettamanti et al., 2005), and that part of the brain is activated in a somatotopic way. Results obtained with transcranial magnetic stimulation (TMS) are contrasting. With a combined TMS and behavioral study Buccino et al. (2005) found a decrease in amplitude of MEPs recorded from hand muscles while listening to hand-action-related sentences (e.g. s/he sewed the skirt), and from foot muscles when listening to foot-related sentences (e.g. s/he

kicked the ball). This finding is quite robust, even if not always replicated (Gianelli & Dalla Volta, 2015). Other TMS studies (Oliveri et al., 2004; Pulvermüller, 2005) and behavioral studies show a facilitation: for example, Scorolli & Borghi (2007) found a facilitation when reading sentences related to the foot and to the mouth and concurrently producing a response with the implied effector. Behaviorally, reading the sentence “he/she sewed the skirt” yielded longer response times with hand than with foot responses system, while the opposite was true for sentences such as “He/she kicked the ball”; interference was also found by Sato et al. (2008), but only with tasks implying deep semantic processing and not with more shallow lexical decision tasks. Overall, the most consistent pattern of results seems to show an early interference (but Gianelli and Dalla Volta (2015) and Pulvermueller (2005) found an early facilitation) in case of congruency between the effector implied by the verb and the one used to respond, and a late facilitation (but Sato, 2008, did not find it). In any case, all results converge in showing the action-language cross-talk. In recent work Miller et al. (2018) performed 8 experiments in which they combined behavioral with ERPs tasks. They found a facilitation in RTs in case of congruency between the effector implied by the sentence and the one involved to respond, but the ERP (Event-related Potentials) analyses showed that ERPs differed for hand versus foot movements, but not for hand- versus foot-associated words. This invites to be cautious as it might suggest that language-related compatibility effects on RTs might emerge before action processing, hence might not be determinant for language comprehension.

1.2 ACE effect. Glenberg and Kaschak (2002) were the first to demonstrate the Action Sentence Compatibility (ACE) effect: when participants process sentences referring to a movement away from or toward their body (e.g. “open/close the drawer”), responses are facilitated in case of congruency between the action implied by a sentence and a real movement, away or toward the body, performed to respond. The typical ACE task is a sentence sensibility evaluation one, in which participants are required to decide whether the sentence makes sense or not – the effects hold however with a variety of slightly different tasks, such as evaluation of words (part vs. no part), and sentence sensibility evaluations (Borghi, Glenberg, & Kaschak, 2004; Kaup, Lüdtke, & Maienborn, 2010), and for a variety of linguistic phenomena (e.g. sentences, words, sentences describing a state, (Kaup et al., 2010). The ACE effect is not exempt from criticism: recently Papesh (2015) has questioned the strength of the ACE effect, showing though Bayesian analyses that only a minority of the published results offer strong evidence for the ACE; one of the problems pointed out by the authors is that some studies lead to a facilitation and some to an interference effect.

1.3 Spatial interference effect. When visual stimuli instead of only words are presented, a reversed effect is obtained, i.e. no facilitation but an interference is reported. Estes and Barsalou (2018) found the spatial interference effect, an effect of attention on language, showing that processing words with spatial associations (e.g., “bird”, “hat”) can reduce the capability to identify an unrelated visual target (e.g., X) at the implied location (i.e., at the top of a display). Even if the reliability of the effect was criticized, Estes and Barsalou (2018) reported a meta-analysis of 37 studies indicating that the effect was reliable. They collapsed studies using single words or sentences, in which the task was to detect the visual target and the target was unrelated to the words.

Overall results from the three lines of research we have outlined reveal that the meaning of the language is intimately tied to the actions it refers to. However, the results obtained are not always coherent. There is certainly a crosstalk between language and action, but some studies report that language processing interferes with action execution while others find a facilitation (notice that similar facilitation and interference effects are also found in the action observation literature (Brass, Bekkering, & Prinz, 2001). Different explanations of these contrasting results have been advanced. The most common is based on timing (e.g. Borreggine & Kaschak, 2006; de Vega, Moreno, & Castillo, 2013), and it has been explained with a model (Chersi, Thill, Ziemke, & Borghi, 2010) that predicts interference when action and language are simultaneously processed, and facilitation in case of delayed processing. Another explanation, which is not necessarily mutually exclusive with the first, points to the ease of integration between the sentence meaning and the motor action/visual stimuli: when the integration is scarce, then interference occurs (Kaschak et al., 2005).

1.4 Action verbs in literal and figurative sense. While numerous studies have demonstrated a tight relationship between language and motor system, only a small subset of studies have investigated whether action sentences still recruit sensorimotor information when used in an abstract sense. For example, if we hear or read the sentence “He does not grasp the concept”, do we still activate the grasping movement? The more relevant to our aims are studies that investigate grounding of figurative language, and particularly those that concern non-idiomatic, novel metaphors/abstract usage. Most results show that also figurative sentences involve areas engaged in processing concrete sentences, and thus are grounded in the sensorimotor system (e.g. Boulenger, Hauk, & Pulvermüller, 2008; Boulenger, Shtyrov, & Pulvermüller, 2012; Desai, Binder, Conant, Mano, & Seidenberg, 2010; Mano et al., 2012; Saygin, McCullough, Alac, & Emmorey, 2009; Wallentin, Østergaard, Lund, Østergaard, & Roepstorff, 2005). There are, however, inconsistencies: some neuroimaging studies found motor/premotor activation for literal but not for figurative

sentences (Aziz-Zadeh, Wilson, Rizzolatti, & Iacoboni, 2006; Raposo, Moss, Stamatakis, & Tyler, 2009). Specifically, Desai et al. (2013) showed that motor activation increased at the reduction of abstractness and conventionality of sentences. At a behavioral level, Scorolli et al. (2011) investigated response times using simple sentences resulting from combinations of concrete and abstract verbs/nouns (e.g. think of/caress the dog/idea). Mixed combinations led to longer response times, especially when the concrete word preceded the abstract one: this shifting cost can be ascribed to the hypothesis that concrete and abstract words are processed in parallel systems, one more linguistic and the other more sensorimotor, in line with the hypothesis of the WAT (Words As social Tools) theory (Borghi et al., 2019; Borghi, Barca, Binkofski, & Tummolini, 2018); this hypothesis is supported by two further fMRI and TMS studies with the same stimuli (Sakreida et al., 2013; Scorolli et al., 2012).

1.5 Action-language cross-talk in different cultures. The aim of our work is to investigate the relationship between language and motor responses using both concrete and abstract sentences in two different languages, Italian and Persian. To the best of our knowledge, studies on the relationship between sentences with action verbs have been conducted so far only with WEIRD (Henrich, Heine, & Norenzayan, 2010a, 2010b) participants, i.e. participants of Western cultures, in North American and European countries. The only exception we are aware of is a study by Dennison & Bergen (2010) that showed that social and cultural practices influence the way people represent action language. They focus on a social practice common in Korean culture, in which people tend to use both hands to give objects to people of higher social status. The authors manipulated the status of the recipient of the presented sentences, using sentences such as “You are now giving a letter to (your) professor / to (your) younger sibling”. The acquired cultural practice is reflected in the ACE effect found: consistently with the acquired behavior, when presented with sentences referring to transfer of an object to high status recipients Korean participants were slower in bimanual responses, while unimanual responses were slower with sentences referring to low status recipients.

Even if this study shows the tight relation language-action in an Eastern culture, it does not compare Eastern and Western cultures using the same task. This is instead what we did in the present work.

Here, we used sentences that referred either literally or metaphorically to motor actions, with no directional information. They were accompanied by a video displaying a movement that could be congruent or incongruent with the one described in the sentence. Participants were asked to reproduce the movement observed in the video, then they had to perform the task evaluating whether the sentence made sense or not. We wanted to render the task as much implicit as possible,

186 hence we opted for asking participants to perform a sentence sensibility judgment rather than
 187 requiring participants to evaluate the congruency between the action and the sentence. Since the
 188 displayed actions could involve the hands, we asked participants to respond by pressing a pedal
 189 when the sentence made sense and to refrain from responding when it did not: it was thus a go-nogo
 190 paradigm. Response times and accuracy were recorded. The reason why we decided to show
 191 participants a video and ask them to perform the observed movement is that we intended to boost
 192 motor activation, in order to verify its relationship with language processing.

193 To investigate whether the relationship between language and movement was the same across the
 194 two different languages/cultures, we submitted the same task to Italian and Iranian participants.
 195 Notice that these two cultures are likely not extreme in their Western/Eastern characteristics: for
 196 example, Italian culture is less individualistic than US culture (Henrich et al., 2010b), Iranian
 197 culture likely differs from East-Asian cultures on a variety of dimensions. Evidence has shown that
 198 belonging to a Western or an Eastern culture influences a variety of cognitive processes, starting
 199 from perception to decisional processes (review in Henrich et al., 2010b): Asian people tend to
 200 perceive the environment in a more holistic way, Western cultures are generally more analytic
 201 (Nisbett & Masuda, 2003); sense of agency differs as well - Western people tend to perceive events
 202 as the outcome of a choice more often than Eastern people (Savani, Markus, & Conner, 2008).
 203 Similarly to other Asian cultures, Iran can be considered as a collectivist culture (Hofstede, 1980),
 204 as testified by the presence of extended families, by the important role played by the ingroup, by the
 205 strong sense of national belonging, and also by some linguistic habits such as the frequent use of the
 206 pronoun “we” instead of “I” (Zampour & Zadri, 1996). Because of the strong differences between
 207 typical WEIRD cultures and Iranian culture, we intended to test whether the compatibility effect,
 208 found in WEIRD cultures, extended also to an Iranian sample.

209 Hypotheses. Based on the reviewed literature, we advanced the following hypotheses:

210 First, we predicted that there would be a difference between congruent and incongruent trials, likely
 211 leading to a facilitation of congruent over incongruent trials since the timer started after the
 212 sentence was presented.

213 Second, we predicted that action sentences would elicit faster responses compared to abstract ones,
 214 in line with the previously discussed results on figurative sentences and on the well-established
 215 concreteness effect, showing that concrete words/sentences are processed faster and recalled better
 216 than concrete ones (Paivio, 1990; Schwanenflugel, Akin, & Luh, 1992).

Third, and more crucially, we advanced the (directional) hypothesis that the congruency action-video with the sentence would be perceived as stronger in the case of concrete sentences, leading to a greater difference in response times between concrete congruent and incongruent trials than between abstract congruent and incongruent trials. As to the cultural and linguistic difference, we advanced two hypotheses, hypothesis four and five. Fourth, we intended to investigate whether the congruency effect we expected to replicate in the Italian sample would be extended or not to a different culture. Finally, we intended to investigate whether using a different language has a different effect with responses to concrete and abstract sentences. We expected the difference between the two languages to be more marked with abstract than with concrete sentences, in line with the idea that linguistic experience is more influential on abstract than on concrete sentences processing (Borghi et al., 2019, 2018).

2. Method

2.1 Sample

Thirty-five Iranian and thirty-eight Italian participants took part in this experiment. All Iranian participants were native Persian speakers (20 females, all but 2 right-handed, mean age 30.5, st dev 3.71 range 25-40), had left Iran for less than 8 years, and were now living in Rome (mean age of permanence in Italy 4 years) They were recruited in dorms of Iranian students, or in Iranian meeting points in Rome. Out of the 35 Iranian participants, only 5 spoke fluent Italian. All thirty-eight Italians were Italian native speakers (19 females, all but 2 right-handed, (mean age 26.6 st dev 4.15) range 20-38). All participants had normal or corrected-to-normal vision. The study was in accordance with the Declaration of Helsinki and approved by the local ethical committee.

2.3 Stimuli and Procedure

For the Persian sample, stimuli consisted of fourteen sensible sentences in Persian (see Table 1 Panel A). Each sentence was composed of a third-person subject, a transitive verb and a concept noun. In seven sentences, the verbs were used with a concrete meaning, in the other seven the same verb were used in a metaphorical sense. For example, the verb “to pull” was used for the concrete sentence “Kif ra roye zamin ke'id/ She pulled the bag on the floor” and for the abstract sentence “Xane ra be atæ ke'id/She set the house on fire”. Additionally, we combined the verbs with the nouns to create seven meaningless sentences e.g. “tækko ra ruye dærya ke'id/ She pulled the

248 sea". The word order of Persian sentences is Subject + Object + Verb, which is the unmarked word
 249 order in Persian. The tense is simple past as it contains the simplest process for a third-person
 250 subject with no extra affix added to the verb. Moreover, as both Persian and Italian languages have
 251 the capacity to be meaningful with no subject in the beginning of sentences (pro-drop parameter in
 252 linguistics), the subject is null on the surface. The sentences were selected by asking to 14 Persian
 253 people (age range of 25-43) to rate them through a seven point Likert-scale according to a list of
 254 parameters, useful to determine the degree of abstractness of the sentence (Villani et al., 2019):
 255 concreteness vs abstractness, imageability (Paivio et al., 1986), emotionality (Ponari et al., 2017),
 256 age of acquisition (Barca et al., 2002), modality of acquisition (Marschark, M., & Wauters, 2003),
 257 body-object interaction (Tillotson et al., 2008), social metacognition (Borghi et al., 2018), quantity
 258 of motion, and perceptual strength (Connell & Lynott, 2012; Lynott & Connell, 2013). The
 259 abstract/concrete sentences were compared for different parameters: abstractness/concreteness
 260 [ASentences=3.97 st dev= 0.84; CSentences=1.92 st dev=0.27, $t(6)=6.99$, $p<.001$], imageability
 261 [ASentences= 4.66 st dev= 0.52; CSentences= 6.42 st dev=0.62, $t(6)=-3.81$, $p<.009$], emotionality,
 262 [ASentences=4.05 st dev= 1.14; CSentences= 3.16 st dev=0.96, $t(5)= 1.20$, $p=.28$], age of
 263 acquisition [ASentences=4.79 st dev=.038; CSentences= 2.93 st dev=0.22, $t(6)=4.81$, $p<.003$],
 264 modality of acquisition [ASentences= 3.83 st dev=0.28; CSentences= 2.48 st dev=.08, $t(6)= 4.27$,
 265 $p<.003$], body-object interaction [ASentences=3.88 st dev= 1.63; CSentences= 1.48 st dev= 0.01,
 266 $t(6)=$, $p<.010$], social metacognition [ASentences= 3.42 st dev= 0.16; CSentences= 1.64 st
 267 dev=0.14, $t(5)=8.15$, $p<.001$], quantity of motion [ASentences=3.70 st dev=1.58; CSentences=
 268 5.12 st dev=0.74, $t(6)=-2.53$, $p<.05$], perceptual strength (hearing) [ASentences=3.94 st dev=0.71;
 269 CSentences= 3.85 st dev 0.76, $t(6)=0.20$, $p= 0.84$], perceptual strength (smelling)
 270 [ASentences=2.09 st dev= 1.35; CSentences= 2.11 st dev=0.80, $t(6)=-0.38$, $p=0.97$], perceptual
 271 strength (touching) [ASentences= 3.57 st dev= 1.57; CSentences=5.09 st dev=0.16, $t(6)=-2.57$,
 272 $p<.05$], perceptual strength (vision) [ASentences=4.36 st dev= 1.16; CSentences= 4.79 st
 273 dev=0.49, $t(6)=$, $p=0.48$], perceptual strength (tasting) [ASentences=1.86 st dev=1.34;
 274 CSentences=1.86 st dev=0.76, $t(6)=$, $p=0.98$] (See Table 2). Three-second video clips showing the
 275 right-hand of an actor performing the action coupled with an object located on the table e.g. ("to
 276 pull the cup on table/to pour the tea/to throw trash") were recorded. In total there were seven video
 277 clips that represented the action verbs. The action verbs were "to screw", "to take", "to throw", to
 278 pull", "to pick up", "to pour" and "to hit". The sentences could be congruent or incongruent with
 279 respect to the action observed in the video and the verb could have either a concrete or an abstract
 280 metaphorical meaning. When the sentences, either abstract or concrete, contained the action verb
 281 referring to the action observed in the video and they were sensible, the trials were categorized as

congruent. On the contrary, when the sentence, either abstract or concrete, contained a verb referring to an action that differed from the displayed one, the trials were categorized as incongruent. No sensible sentences were entered as catch trials serving the scope to keep participants focused on the task. The fourteen sensible sentences were combined with the seven videos; we thus obtained seven congruent_abstract trials, seven congruent_concrete trials, seven incongruent_abstract trials and seven incongruent_concrete trials and seven trials consisting of no sensible sentences. In total seventy trials were randomly administered in two different sessions composed each one of thirty-five trials.

For the Italian sample, stimuli consisted of eighteen sensible Italian sentences (See Table 1 Panel B) composed of a third-person subject, a transitive verb and a concept noun. Nine of them referred to concrete contexts e.g. “Lei afferra la tazza/She grasps the cup”, the others nine were metaphorical sentences e.g. “Lei afferra il concetto/She grasps the concept”, the remaining nine were meaningless sentences e.g. “Lei afferra il vulcano/She grasps the volcano”. The sentences were selected by asking to 17 Italian people (18-51) to rate them through the same seven point Likert-scale above-mentioned for the Iranian group. The abstract/concrete sentences were compared for different parameters: abstractness/concreteness [ASentences= 6.16 st dev=0.41; CSentences= 1.71 st dev= 0.41, $t(8)=34.3$, $p<.001$], imageability [ASentences=2.24 st dev= 0.81; CSentences=6.40 st dev=0.23, $t(8)=-13.9$, $p<.001$], emotionality, [ASentences=3.72 st dev=0.77; CSentences= 3.54 st dev=1.58, $t(8)=0.51$, $p=0.62$], age of acquisition [ASentences = 5.08 st dev=0.97; CSentences=2.91 st dev=0.73, $t(8)= 5.72$, $p<.001$], modality of acquisition [ASentences= 5.54 st dev=0.22; CSentences= 2.99 st dev=0.86, $t(8)=9.14$, $p<.001$], body-object interaction [ASentences=6.38 st dev= 1.31; CSentences= 1.88 st dev= 0.46, $t(8)=9.9$, $p<.001$], social metacognition [ASentences= 2.99 st dev= 0.45; CSentences= 1.33 st dev=0.17, $t(8)=12.48$, $p<.001$], quantity of motion [ASentences=2.04 st dev=.030; CSentences=5.39 st dev=0.35 $t(8)=-19.23$, $p<.001$], perceptual strength (hearing) [ASentences=1.89 st dev=.055; CSentences=2.72 st dev= 1.68, $t(8)=-1.35$, $p=.21$], perceptual strength (smelling) [ASentences=1.26 st dev=0.12; CSentences=2.09 st dev=1.17, $t(8)=-2.24$, $p=.055$], perceptual strength (touching) [ASentences=1.36 st dev=0.32; CSentences=4.95 st dev=1.02, $t(8)=-11.32$, $p<.001$], perceptual strength (vision) [ASentences=1.77 st dev=0.35; CSentences=4.95 st dev=0.60, $t(8)=-14.97$, $p<.001$], perceptual strength (tasting) [ASentences=1.21 st dev=0.07; CSentences=1.59 st dev=0.54, $t(8)=-2.05$, $p=0.08$] (See Table 2). The nine action verbs in the video clips were “to take”, “to grasp”, “to pet”, “to feed”, “to unhinge”, “to hold”, “to pull”, “to divert”, “to squeeze”. The eighteen sensible sentences were combined with the nine videos in order to have nine

congruent_abstract trials, nine congruent_concrete trials, nine incongruent_abstract trials, nine incongruent_concrete trials and nine trials with no sensible sentences. In total ninety trials were administered in a random order in two different sessions composed each one of forty-five trials. The experimental task was administered on a PC utilizing E-Prime software (Version 3). The participants sat at 60 cm from a 15 inches computer monitor in a dimly lit room. They were asked to maintain a comfortable position and to keep the feet on a pedal connected with the laptop through a Multifunctional response box (Chronos PST100430 model). Participants were instructed to look at a fixation cross that remained on the screen for 1000 ms, then the video started followed by a black screen lasting 5000 ms. During this time window, participants were asked to perform the pantomime of the observed action three/four consecutive times. Immediately after, a sentence lasting 3000 ms appeared on the screen and participants were instructed to press a pedal on the ground only when the sentence was sensible, otherwise they were asked to refrain from responding. All participants were informed that their response times (RTs) would be recorded and were invited to respond as quickly as possible while still maintaining accuracy (Figure 1).

Table 1 Panel A)

Persian concrete sentences			
	Sentences	Literary meaning	Meaning
1	بچه را زد	S/he hit the child	S/he hit the child
2	کیف را روی زمین کشید	S/he pulled the bag on the floor	S/he pulled the bag on the floor
3	میوه‌ها را از درخت چید	S/he picked the fruits from the tree	S/he picked the fruits from the tree
4	به سبب از پیش گرفت	S/he took an apple from him	S/he took an apple from him
5	اشغال را روی زمین انداخت	S/he threw the trash on the floor	S/he threw the trash on the floor
6	لامپ را پیچید	S/he screwed the light bulb	S/he screwed the light bulb
7	ظرف‌ها را روی زمین ریخت	The plates poured on the floor	The plates poured on the floor
Persian abstract sentences			
	Sentences	Literary meaning	Meaning
1	به استاد ایمیل زد	S/he sent an email to the professor	S/he sent an email to the professor
2	خانه را به آتش کشید	S/he pulled the house to the fire	S/he set the house on fire
3	اسباب خانه را چید	S/he picked up the furniture	S/he decorated the home
4	به بوس از پیش گرفت	S/he got a kiss from him	S/he got a kiss from him
5	اسم او را از قلم انداخت	S/he dropped his/her name	S/he forgot to consider her name
6	همه‌چیز را پیچید	S/he screwed the party	S/he found an excuse to avoid the party
7	آبروش ریخت	Her/his face poured	S/he lost his face

Table 1 Panel B)

Italian concrete sentences			
	Sentences	Literary meaning	Meaning
1	Lei/Lui accarezza il cane	S/he caresses the dog	S/he caresses the dog
2	Lei/Lui coglie un fiore	S/he picks a flower	S/he picks a flower
3	Lei/Lui afferra la tazza	S/he grasps the cup	S/he grasps the cup
4	Lei/Lui tira la corda	S/he pulls the rope	S/he pulls the rope
5	Lei/Lui <u>impugna un'arma</u>	S/he holds a weapon	S/he holds a weapon
6	Lei/Lui devia la palla	S/he diverts the ball	S/he diverts the ball
7	Lei/Lui nutre il figlio	S/he feeds the son	S/he feeds the son
8	Lei/Lui scardina la porta	S/he unhinges the door	S/he unhinges the door
9	Lei/Lui stringe una spugna	S/he squeezes the sponge	S/he squeezes the sponge
Italian abstract sentences			
	Sentences	Literary meaning	Meaning
1	Lei/Lui <u>accarezza un'idea</u>	S/he caresses an idea	S/he has an idea
2	Lei/Lui <u>coglie un'occasione</u>	S/he picks an occasion	S/he takes an occasion
3	Lei/Lui <u>afferra un concetto</u>	S/he grasps a concept	S/he grasps a concept
4	Lei/Lui tira le conseguenze	S/he pulls the consequences	S/he draws the consequences
5	Lei/Lui <u>impugna una sentenza</u>	S/he holds a judgment	S/he takes the issue
6	Lei/Lui devia il discorso	S/he diverts a speech	S/he <u>meanders</u> in a topic
7	Lei/Lui nutre un dubbio	S/he feeds a doubt	S/he has the doubts
8	Lei/Lui <u>scardina un'accusa</u>	S/he unhinges an accusation	S/he thwarts an accusation
9	Lei/Lui <u>stringe un'amicizia</u>	S/he squeezes a friendship	S/he holds a friend

Experiment's sentences selected in the Persian (Panel A) and Italian (Panel B) sample.

Table 2)

	Italian sample		Persian sample	
	Concrete	Abstract	Concrete	Abstract
ABSTRACTNESS/CONCRETENESS	1.71 sd= 0.41	6.16 sd=0.41 *	1.92 sd=0.27	3.97 sd= 0.84*
IMAGEABILITY	6.40 sd=0.23	2.24 sd= 0.81*	6.42 sd=0.62	4.66 sd= 0.52*
EMOTIONALITY	3.54 sd=1.58	3.72 sd=0.77	3.16 sd=0.96	4.05 sd= 1.14
AGE OF ACQUISITION	2.91 sd=0.73	5.08 sd=0.97*	2.93 sd=0.22	4.79 sd=.038*
MODALITY OF ACQUISITION	2.99 sd=0.86	5.54 sd=0.22*	2.48 sd=0.08	3.83 sd=0.28*
BODY-OBJECT INTERACTION	1.88 sd=0.46	6.38 sd= 1.31*	1.48 sd= 0.01	3.88 sd= 1.63*
SOCIAL METACOGNITION	1.33 sd=0.17	2.99 sd= 0.45*	1.64 sd=0.14	3.42 sd= 0.16*
QUANTITY OF MOTION	5.39 sd=0.35	2.04 sd=.030*	5.12 sd=0.74	3.70 sd=1.58*
PERCEPTUAL STRENGTH HEARING	2.72 sd=1.68	1.89 sd=.055	3.85 sd= 0.76	3.94 sd=0.71
PERCEPTUAL STRENGTH SMELLING	2.09 sd =1.17	1.26 sd=0.12	2.11 sd=0.80	2.09 sd=1.35
PERCEPTUAL STRENGTH TOUCHING	4.95 sd=1.02	1.36 sd=0.32*	5.09 sd=0.16	3.57 sd= 1.57*
PERCEPTUAL STRENGTH VISION	4.95 sd=0.60	1.77 sd=0.35*	4.79 sd=0.49	4.36 sd= 1.16
PERCEPTUAL STRENGTH TASTING	1.59 sd=0.54	1.21 sd=0.07	1.86 sd=0.76	1.86 sd=1.34

Averaged scores along all the psycholinguistic dimensions for concrete and abstract sentences in the Italian and Persian sample,

Figure 1)

Experimental procedure: Participants were instructed to look at a fixation cross for 1000 ms. During a time window of 5000 ms participants were asked to perform the pantomime of the observed action. Immediately after, a sentence appeared on the screen and participants were instructed to press a pedal on the ground only when the sentence was sensible, otherwise they were asked to refrain from responding.

3. Results

The analysis was restricted to 4034 reaction times. The analyses we performed in the sentence sensibility task were restricted to the sensible sentence, the non-sensible sentences were not included because they were not informative for the experimental question, indeed their role was just to keep the attention on the task and to make the task implicit. Hence, all the errors we reported refer to false negative (thinking that the sentence is without sense when it is not the case). From the overall possible responses, we discarded 662 trials which were not given responses. Among all the errors, 493 (74.5 %) involved abstract sentences, the remaining 169 (25.5 %) were related to concrete sentences. Such percentage discrepancy clearly indicates that in the sensibility task the abstract sentences were perceived as more complex than the concrete sentences. Following a stepwise procedure, in the first model we included fixed effects for the variables Congruency, Category, Group and we added random intercepts for Participants and the Sentences nested in the Participants factor. In a second, third and fourth models, we excluded in the following order the variables: Congruency (congruent, incongruent), Category (abstract, concrete), Group (Italians,

Persians), in order to investigate the main effect of each factor. In the fifth, sixth, and seventh model, we investigated the two-way interactions with the addition of all the fixed factors. Specifically, in model fifth we entered the interaction Category x Congruency, in the sixth model the interaction Congruency x Group, and in seventh model the interaction Category x Group. We constantly kept in all the models the random intercepts for Participants and Sentences nested in the Participants factor. Finally, in eighth model we entered the three-way interaction Group x Congruency x Category. We compared the eighth model with all these models. Model eight was the one with the best fit (see Table 3), suggesting that the three-way interaction better explained the data. This model yielded a significant main effect of the Category ($F(1,3215)=14.6683$, $p=.0001$) due to the fact that overall abstract sentences showed slower RTs (1481, $SE=38.3$) than concrete sentences (1456, $SE=38.2$) (Concreteness effect, Hypothesis 2). The main effect of the Congruency was also approaching the significance ($F(1,3216)=3.3403$, $p=0.0677$), congruent conditions (1486, $SE=38.2$) were slower than incongruent conditions (1451, $SE=38.2$). Both main effects are however qualified by the interactions. The 3-way interaction Group X Congruency X Category was significant ($F(1,3215)=7.1218$, $p=0.0077$) Figure 2). In the Italian group, Tukey post hoc comparisons indicate that in the congruent condition, concrete sentences (1372, $SE=53.7$) were processed faster than abstract sentences (1534, $SE=54.4$), ($t(3216)=7.26$ $p<.0001$). The same difference was present in the incongruent condition: concrete sentences (1433, $SE=53.8$) were processed faster than abstract sentences, even if the effect was less marked (1505, $SE=54.2$), ($t(3216)=3.23$ $p=.0273$). In the Italian sample our hypothesis that a concreteness effect would exist was thus confirmed (Hypothesis 2). Moreover, Tukey post hoc comparisons show that, in keeping with our predictions, concrete sentences (1372, $SE=53.7$) were processed faster in the congruent than in the incongruent condition (1433, $SE=53.8$), although this difference was just approaching the significance ($t(3216)=-2.923$, $p=.0685$), suggesting a tendency towards a facilitation effect (Hypothesis 3).

In contrast with the Italian group, in the Persian group, Tukey post hoc comparisons indicate that abstract sentences (1476, $SE=56.8$) were processed faster than concrete sentences in the congruent condition (1562, $SE=56.9$), ($t(739)=-3.17$ $p=.0336$), while the difference between abstract sentences (1409, $SE=57.0$) and concrete ones (1457, $SE=56.9$) was not significant in the incongruent condition, ($t(739)=-1.79$ $p=.6267$). Furthermore, concrete sentences (1562, $SE=56.9$) were processed significantly slower in the congruent than in the incongruent condition (1457, $SE=56.9$) ($t(3216)=4.072$, $p=.0012$). Abstract sentences (1476, $SE=56.8$) in the congruent condition, instead, were not processed significantly slower than abstract ones in the incongruent condition (1409,

SE=57.0), ($t(3216)=2.627$, $p=.1464$). The results show an inhibition effect, driven by the concrete sentences.

All the other Tukey Post hoc comparisons between the Italian and Persian groups were not significant ($p>.2461$).

The 3-way interaction can be better qualified by the significant 2-way interaction Group x Category ($F(1,739)=51.33$, $p<.0001$) Figure 3) and by the 2-way significant interaction Group x Congruency ($F(1, 3216)=20.14$, $p<.0001$) Figure 4).

In the 2-way Group x Category interaction, Tukey Post Hoc comparisons indicate that in the Italian group, concrete sentences (1403, SE=52.7) were processed significantly faster than abstract sentences (1520, SE=53.0) ($t(3216)=7.36$, $p<.0001$) (concreteness effect, Hypothesis 2). On the contrary, in the Persian group, Tukey post hoc comparisons show that abstract sentences (1442, SE=55.4) were processed significantly faster than concrete sentences (1510, SE=55.4), ($t(739)=-3.32$, $p=.0052$). In the 2-way Group x Congruency interaction, Tukey post hoc comparisons indicate that in the Italian group there was no difference between the congruent (1453, SE= 52.8) and the incongruent condition (1469, SE= 52.8), ($t(3216)=-1.006$, $p=.7461$). Crucially, in the Persian group the sentences were processed significantly slower in the congruent condition (1519, SE=55.2) than in the incongruent condition (1433, SE= 55.2), ($t(3216)=4.74$, $p<.0001$), showing the inhibition effect.

425

426 Table 3)

			Information criteria		
			AIC	BIC	- 2LL
First Model	Fixed Effects	Group, Congruency, Category	59771.48	59815.60	-29878.74
	Random Effects	Participant/sentence			
Second Model	Fixed Effects	Group, Category	59772.72	59810.54	-29880.36
	Random Effects	Participant/sentence			
Third Model	Fixed Effects	Group, Congruency	59784.45	59822.26	-29886.22
	Random Effects	Participant/sentence			
Fourth Model	Fixed Effects	Category, Congruency	59769.56	59807.37	-29878.78
	Random Effects	Participant/sentence			
Fifth Model	Fixed Effects	Group, Category * Congruency	59770.54	59820.96	-29877.27
	Random Effects	Participant/sentence			
Sixth Model	Fixed Effects	Category , Group * Congruency	59754.12	59804.54	-29869.06
	Random Effects	Participant/sentence			
Seventh Model	Fixed Effects	Congruency, Group * Category	59723.08	59773.50	-29853.54
	Random Effects	Participant/sentence			
Eighth Model	Fixed Effects	Group* Category* Congruency	59700.00	59769.33	-29839.00
	Random Effects	Participant/sentence			

AIC) Akaike's information criterion; BIC) Schwarz's Bayesian criterion; -2LL) -2 log-likelihood

427

428

Information criteria on the linear mixed models performed on the entire sample.

429

430

431

432

433

Figure 2)

The graph shows the predicted values of the outcome variables in the all the combinations included in the model. Shaded bands represent the confidence intervals (95%).

Congruency condition: in the Italian sample concrete sentences were processed significantly faster than abstract sentences; in the Persian sample abstract sentences were processed significantly faster than concrete sentences.

Incongruency condition: in the Italian sample concrete sentences were processed significantly faster than abstract sentences; in the Persian sample RTs of concrete and abstract sentences did not differ.

Figure 3)

The graph shows the predicted values of the outcome variables in the all the combinations included in the model

Shaded bands represent the confidence intervals (95%).

Group* Congruency interaction: in the Italian sample there was no difference between the congruent and incongruent condition; in the Persian sample stimuli were processed significantly faster in the incongruent than in the congruent condition.

466

467 Figure 4)

468

469 The graph shows the predicted values of the outcome variables in the all the combinations included in the model

470 Shaded bands represent the confidence intervals (95%).

471 Group* Category interaction: in the Italian sample concrete sentences were processed significantly faster than abstract
 472 sentences; in the Persian sample abstract sentences were processed significantly faster than concrete sentences.

473

474

475 4. Discussion

476 The results clearly show that action sentences are grounded in action, even if the extent of their
 477 grounding differs as a function of the abstractness level. More crucially, the marked differences
 478 between Iranians and Italians are food for thought and induce a reflection. In the next pages, we will
 479 first summarize the main results and the main differences between the two groups, then
 480 provide/attempt some possible explanations.

Before summarizing the data, a caveat. The fact that the Iranians who participated to the study had been exposed to the Italian language and culture might constitute a potential limitation of this work. However, all our participants were late bilinguals, only 5 of 35 spoke fluent Italian, and they frequented mostly Iranians. Furthermore, research on bilinguals show that they have a flexible linguistic organization (e.g. Athanasopoulos, & Avello, 2012). When tested in their own language, participants tend to revert to the structures used in their own language. For example, Chinese bilinguals tend to use more taxonomic conceptual relations when they speak in English, more thematic ones when they speak in Chinese (Li-Jun, Zhang, & Nisbett, 2004). In addition, age had a marked effect of the degree of cognitive shift toward the L2, as revealed by studies on time (Boroditsky, 2001), and all our participants arrived in Italy when they were adults. Based on these considerations, we think that the exposure to the Italian language and culture might not have markedly influenced the results. However, future research should shed better light on the possible fine-grained distinctions between the performance of Iranians living in Iran and Iranian living elsewhere.

Italians: The predicted congruency effect (**Hypothesis 1**) was not present/not significant **per se but it was modulated by the interaction with Category in the three-way interaction**. In line with our expectations, evaluating the matching between the action and the sentence was easier for concrete than for abstract sentences (Hypothesis 2, concreteness effect); this advantage of concrete over abstract sentences was present both for the congruent and the incongruent condition, but was slightly more marked in the congruent condition, in line with our predictions (Hypothesis 3).

Iranians: The pattern of results of Iranian participants did not match that of Italians; surprisingly, it was quite different. First of all, a reverse congruency effect was significant, indicating that the congruent condition was slower than the incongruent one; furthermore, the advantage of concrete congruent trials we found in the Italian sample was not extended to the Persian culture. Hence, the hypothesis that the congruency and concreteness effects would be extended to the Persian sample was not confirmed (Hypothesis 4).

Furthermore, in the congruent condition abstract sentences were processed faster than concrete ones. This profoundly differs from what happens in the Italian sample: as figure 2 clearly shows, in the Persian sample the condition with slowest response times is that of concrete congruent trials, i.e. the faster condition in the Italian sample. Apparently, when reading a sentence, Iranians simulate the mentioned action; this simulation interferes with the actions they observe and perform, generating an inhibition in the congruent condition. This inhibition is particularly marked with

concrete sentences, consistently with the fact that they are grounded to a greater extent in the sensorimotor system, but is present also with abstract sentences. Even if in the incongruent condition abstract and concrete sentences did not differ, through a visual inspection of the data we notice that the fastest RTs are elicited by incongruent abstract sentences, i.e. by the cases in which the sensorimotor system is less activated.

As to Hypothesis 5, we did not confirm our expectations that the difference across the two languages would be more marked for abstract than for the concrete sentences.

Overall, the comparison between the two samples allow us to advance some considerations:

1) For Italians, it seems that language and action are quite integrated, while for Iranians they are processed separately. The inhibition found in the Iranian sample might reflect an overload due to the fact that the motor system is activated by the video/movement and that this exerts a priming effect on the motor activation evoked by the sentence.

.

2) The distinction between concrete and abstract sentences seems to be more marked in Italian than Iranian participants. In the Italian sample we found a facilitation with concrete sentences in both the congruent and incongruent condition, and an opposite pattern with abstract sentences; in contrast, in the Persian sample **the 3-way interaction shows that in the congruent condition** abstract sentences were processed faster than concrete ones, while in the incongruent condition no difference was present between concrete and abstract sentences. The higher continuity between concrete and abstract sentences can be owing to the fact that Persian is more a literary/metaphoric language (poems, literature, etc.), and also that abstract sentences in Persian seem to be more embodied than in Italian, i.e. concrete and abstract sentences seem to rely on a common scheme to a larger extent than in Italian.

Seyed Ghorab (2012), referring to the role and importance of metaphor and figurative speech in the Persian language from the very old times declares "metaphors are the heart of Persian poetry. They are used for a wide range of purposes in different genres". He argues that the poet's professional survival rests on their ability to contrive original metaphors within the established literary conventions. As metaphor is very important in poetry for Persians, it has entered in the ordinary life of people, since poetry is considered one of the most significant artistic achievement of Persia (e.g. Yarshater, 1962). You easily can trace variations of everyday talk of people in poems of old famous poets such as, Khayam (1048-1131), Rumi(1207-1273), Hafez (1325-1389), who are not only famous in Iran but internationally appreciated. In sum, some metaphoric expressions have entered in the life of Iranian people and have become independent from the concrete meaning they

originally are extracted from. You can even trace the Persian sentences of the experiments of this paper in the poems of Hafez or Rumi. For instance, once hearing the sentence “Xane ra be atattke□id/” (literary “to pull the house on the fire”) which means to set the house on fire, Persians immediately think of the action of burning, not of pulling.

A further reason of the differences in the factor Category can be owing to differences of Perceptual Strength across the two languages. Notice that in the two groups there was a difference in Perceptual Strength: abstract and concrete sentences differed only for touching in the Persian set while they differed also for vision in the Italian set. To verify whether differences in Perceptual Strength across the two languages might affect the results, we run mixed model analyses. The analyses are reported in the Appendix. Overall, our results indicate an important role of perceptual strength, in line with the hypothesis of Connell & Lynott (2012). Across the two groups we found that an increase in perceptual strength led to faster response times. However, perceptual strength differently influences the two languages: it loaded more on concrete items in the Persian sample, more on abstract items in the Italian sample. This different role of perceptual strength might thus contribute to explain the differences in the concreteness effect, which was present in the Italian sample but not in the Persian one (See Appendix).

It remains to be explained why with concrete congruent sentences we find an inhibition in Persian but a tendency towards facilitation in the Italian sample. The reason underlying contradictory results – interference and facilitation – has been extensively debated in the literature on action-language integration. A possible reason underlying such contradictory results lies in the timing: interference seems to occur between 160 and 500 ms after stimulus presentation, whereas facilitation becomes evident between 550 and 800 ms after sentence appearance (Borreggine & Kaschak, 2006; Boulenger et al., 2006; de Vega, Robertson, Glenberg, Kaschak, & Rinck, 2004). The model by Chersi et al. (2010), based on a network with a chain organization, explains the divergent results on language and effectors in terms of timing of motor chains activations. The early interference is due to the fact that the motor system is activated concurrently by the sentence and by the movement; the late facilitation is another manifestation of the same process, i.e. an aftereffect of this early overload of the motor system (Chersi et al., 2010). Results found by Liepelt et al. (2012) are convergent with this model: participants were required to execute a hand opening or closing action in response to the color (blue or red) of the words “open” and “close”. Seeing the word automatically evoked a gesture, leading to an advantage of congruent trials (word open-opening gesture). The same results were obtained in further experiments in which participants were required to say “open” or “close” in response to a green or a red cue displayed above a human hand performing either an opening or a closing action. The results matched those of the first experiment:

580 congruent trials are faster than not congruent ones, consistently demonstrating that there is a
 581 bidirectional crosstalk between language and motor system. A neutral condition was then added, in
 582 which a hand remained stationary during the task. Results confirm this showing that semantically
 583 non-corresponding action word pairings lead to interference, consistently with the model by Chersi
 584 et al. (2010) that predicts interference when action and language are simultaneously processed, and
 585 facilitation in case of delayed processing.

586 In our study, the contradictory results cannot be ascribed to overall timing, since the exposure time
 587 is the same for Italians and Iranians.

588 Two possible explanations of the contradictory results are possible. The first reflects a linguistic
 589 difference between Italian and Persian. In the Persian sentences the verb is placed at the end of the
 590 sentence, in contrast in Italian it is located immediately after the subject. Such grammatical
 591 difference could have contributed to create in the Persian sample a shorter temporal interval
 592 between the simulation of the action triggered by the sentence and the motor response than in the
 593 Italian sample. Dennison and Bergen (2010) provided this explanation for the interference result
 594 they found with an ACE paradigm in Korean. We are not incline to favour this explanation because
 595 we considered the congruency between the simulation induced by the video and that elicited by the
 596 sentence – in this case, in the Persian sample the distance is longer. Furthermore, Dennison and
 597 Bergen used an ACE paradigm in which sentence and motor responses were concurrent, while we
 598 did not.

599 A plausible explanation of the inhibition we found in the Iranian sample is owing to the fact that
 600 information derived from language and from vision/action are scarcely related and need to be
 601 integrated online, generating an overload. In this respect, Estes et al. (2015) provides an explanation
 602 of spatial interference that can be useful for us. They asked participants to identify related or
 603 unrelated visual targets above or below a cue word that had high or low spatial associations (e.g.
 604 cloud vs. puddle). They found a facilitation when the target was related to the cue, and interference
 605 when they were not related. A similar explanation has been offered by Kaschak et al. (2005), who
 606 ascribed the interference effect found when participants listened to sentences and simultaneously
 607 observed black and white displays moving in the same/opposite direction to a different degree of
 608 “integrability”, i.e. to the extent to which the perceptual stimuli can be integrated with the content
 609 of the sentence. For example, a picture of a car can be easily integrated with the content of the
 610 sentence “The car approached you,” whereas the black-and-white stimuli used could not, thus
 611 generated interference. Hence, when the visual/motor stimulus match with the verbal one there is a

612 facilitation, when they do not, or they cannot be easily integrated, then there is an interference.
 613 Following this interpretation, it seems that in Persian action and language are separately coded and
 614 need to be integrated online, requiring resources and time. Conversely, in Italian action and
 615 language are easily integrated online, thus we find a tendency towards facilitation in concrete
 616 sentences. But which is the reason of this difference between Italians and Iranians? One possibility
 617 is that it depends on factors related to the specificities of the two languages – for example, the
 618 writing direction is opposite (left-to-right in Italian and right-to-left in Persian), and as a
 619 consequence, there might be a different hemispheric action-language lateralization in the two
 620 languages. Furthermore, the orthography is more transparent in Italian than in Persian. However, it
 621 seems unlikely that such inhibition/facilitation depends on merely linguistic factors. The most
 622 plausible explanations we came up with relied on the gesture-language system. The Italian gesture
 623 system is more structured and more integrated with language compared to the Persian one. A wide
 624 literature shows that, compared to other populations, Italians have a rich gesture vocabulary, and
 625 produce a lot of gestures in everyday communication (Colletta et al., 2015); notably, the Italian
 626 gesture system is particularly structured and includes many conventional gestures (De Jorio, 2000;
 627 Diadori, 1990; Efron, 1941; Kendon, 2004; Munari & Saglietti, 1994) (but see (Pettenati, Sekine,
 628 Congestri, & Volterra, 2012) showing that this Italian specificity does not characterize children). As
 629 to Persian, using gestures has been for long banished. Nowadays in Iran, moving hands is accepted
 630 and even common, especially in academic spaces. However, until the last decades moving hands
 631 while talking was considered impolite as it was the sign of getting control and authority in a
 632 discourse. Elderly people would get annoyed to see a younger person move hands in a conversation
 633 with them and they hardly would do it themselves. Even nowadays, when people and especially
 634 men intend to show their respect for authoritative others, they put one hand on another hand and
 635 take them before their body. The tendency to avoid moving hands when talking with others or
 636 sitting beside people with higher authority could have roots in religious believes considering
 637 quotes from the Prophets and Imams that advise people to have control on their body to respect
 638 others. For instance, Imam Sadegh says "Do not look at your parents' eye unless with kindness; do
 639 not let your voice get higher than theirs; do not let your hands go upper than their hand; and never
 640 walk before them (Majlisi, 1986:79)." The governmental religious website, which is
 641 promulgating Islamic ways of communication, declares that according to Islamic etiquette you
 642 would better not to imply anything through your eye, eyebrow or hand when talking (Tebyan,
 643 2017). Around two decades ago children were told to sit with their hands on their knees without
 644 moving in family gatherings, and in the classroom when teachers asked them to go in front of the
 645 blackboard to answer questions the polite position was standing with their hands on the side. In

addition, when sitting on their bench or chair the polite position was putting their hands on knees or in folded arms style to prevent any movement. The habit to repress gestures and movements while talking can be the cause of the inhibition we found: the linguistic and action systems would be difficult to integrate, hence require more time when simultaneously activated.

Conclusion

We performed two experiments aimed at investigating the cross-talk between concrete and abstract action sentences and videos representing them in two different cultures/languages, the Italian and the Iranian one. The results confirm the tight relationship between language and action, stronger for concrete than for abstract sentences. Strikingly, the results reveal a marked cultural/linguistic difference: while observing a video and imitating an action inhibits concrete congruent sentences in the Iranian sample, it leads to a trend towards facilitation of the same ones in the Italian sample. The results can be ascribed to the higher integration between gestures and language in Italians, and to the tendency to avoid movement when talking widespread in Iranians. Overall, our results help to shed light on the possible causes of facilitation/interference-inhibition and suggest that taking into account of the culture to which participants belong is of paramount importance to understand in depth the mechanisms responsible for contrasting results.

Appendix

To understand the possible role Perceptual Strength exerts on our results, we computed a normalized index for each sentence weighted on the range of values attributed to all the abstract/concrete sentences within each perceptual component (vision, touch, smell, taste, hear) in the entire sample. We averaged the weighted indexes in order to obtain a unique value of Perceptual Strength ranging from 0 to 1 for each Italian and Persian sentence. We adopted a stepwise procedure, as those already described in the manuscript. We maintained as random intercepts participants and sentences and we combined in 51 models all the possible combinations of the fixed factors and their two way/ three-way interactions with the covariate. The high number of models was obtained because we considered the two-interactions and the three-way interactions among all the factors and we eliminated from the model each factor following a stepwise procedure. We compared all these models with a full model expressed by the interaction of the Group, Congruency, Category and Perceptual Strength with the addition of all the fixed factors and as random effects the participants and the sentence. Such model resulted to be the best compared with the others. The model yielded a significant four-way interaction Group X Category X Congruency X Perceptual Strength ($F(1,3210)=4.52$, $p=0.0336$). In order to explore the four-way interaction, we performed two separate analyses, one for each sample. In the Italian sample, following a stepwise procedure, we compared 15 models with Congruency, Category and Perceptual Strength as fixed factors and their interaction, again participants and sentences were included as random factors. The best model was the full model expressed by the interaction Congruency X Category X Perceptual Strength. This model yielded a significant main effect of the Category ($F(1,1961)= 60.87$ $p<.0001$). Both the two-way interaction Congruency X Category ($F(1,1961)= 8.857$ $p=0.003$) and the two-way interaction Perceptual Strength X Category (Figure A) were significant ($F(1,1961)= 17.61$ $p=0.006$). Crucially, the three-way interaction Congruency X Category X Perceptual Strength was also significant ($F(1,1961)=7.39$, $p=0.0066$) (Figure B). In the Persian sample, we followed the identical stepwise procedure adopted in the Italian sample, and we compared again 15 models. The best model was again the full model expressed by the fixed factors and their interaction Congruency X Category X Perceptual Strength; in which participants and sentences were included as random intercepts. This model yielded a significant main effect of the Category ($F(1,433)= 9.21$ $p=.0025$) and of the Congruency

687 ($F(1,1249)= 16.71$ $p<0.0001$). The two-way interaction Perceptual Strength X Category was significant ($F(1,433)= 11.69$ $p=0.0007$)
 688 (Figure C) and the two-way interaction Congruency X Perceptual Strength resulted significant ($F(1,1249)= 28.20$ $p<.0001$) (Figure
 689 D) as well. Crucially, the three-way interaction Congruency, Category and Perceptual Strength was not significant ($F(1,1249)=$
 690 0.2352 $p=.6278$).

691 Figure A)

693

694

695 Italian sample- Perceptual Strength strongly modulates the facilitation effect in the Abstract sentences: small Perceptual strength
 696 increments drastically reduce the RTs in Abstract sentences. Concrete sentences are instead not modulated by Perceptual Strength.

697

698

699 Figure B)

702

703 Italian sample- Perceptual strength strongly modulates the facilitation effect in Abstract sentences: small increments in Perceptual
 704 strength drastically reduce the RTs in Abstract sentences in the congruent condition. Concrete sentences show instead an opposite
 705 trend: RTs are slower, the more Perceptual Strength increases. In the incongruent condition, there is no difference between
 706 processing Abstract and Concrete sentences: the graphs show a general facilitation in the responses at the increase of Perceptual
 707 strength.

708

709

Figure C)

Persian sample- Perceptual strength strongly modulates the facilitation effect in Concrete sentences: small Perceptual strength increments drastically reduce RTs in Concrete sentences. Processing of Abstract sentences, instead is not modulated by Perceptual Strength.

Figure D)

Persian sample- Perceptual strength strongly modulates the facilitation effect in the congruent condition: small Perceptual strength increments drastically reduce RTs in the congruent condition. In the incongruent condition, instead, RTs slow down with Perceptual Strength increments.

Open Practices Statement

The raw data for all analyses are available at:

<https://osf.io/w3m7t/>

Acknowledgments

The authors would like to thank Giulia Liorni for data collection, Luca Simione, Alberto Accanito, Vanessa Era for statistical help, Luca Tummolini, Laura Barca Martin Fischer and Fariba Ghatreh for feedback and discussions.

This research was funded by the grant Abstract sentences, language and sociality - protocol n. RG11715C7F1549F7, 2017 from Sapienza University of Rome to Anna Borghi and by the INTENSS H2020-MSCA-IF-2017 grant n. 796135 to Federico Da Rold and Anna Borghi.

References

- Athanasopoulos, P., & Aveludo, F. (2012). Linguistic relativity and bilingualism. *Memory, language, and bilingualism: Theoretical and applied approaches*, 236-255.
- Aziz-Zadeh, L., Wilson, S. M., Rizzolatti, G., & Iacoboni, M. (2006). Congruent embodied representations for visually presented actions and linguistic phrases describing actions. *Current biology*, 16(18), 1818-1823.
- Barca, L., Burani, C., & Arduino, L. S. (2002). Word naming times and psycholinguistic norms for Italian nouns. *Behavior Research Methods, Instruments, & Computers*, 34(3), 424-434.
- Borghi, A. M., Barca, L., Binkofski, F., Castelfranchi, C., Pezzulo, G., & Tummolini, L. (2019). Words as social tools: language, sociality and inner grounding in abstract concepts. *Physics of life reviews*, 29, 120-153.
- Borghi, A. M., Barca, L., Binkofski, F., & Tummolini, L. (2018). Abstract concepts, language and sociality: from acquisition to inner speech. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 373(1752), 20170134.

- Borghi, A. M., Glenberg, A. M., & Kaschak, M. P. (2004). Putting words in perspective. *Memory & Cognition*, 32(6), 863-873.
- Boroditsky, L. (2001). Does language shape thought?: Mandarin and English speakers' conceptions of time. *Cognitive psychology*, 43(1), 1-22.
- Borreggine, K. L., & Kaschak, M. P. (2006). The action-sentence compatibility effect: It's all in the timing. *Cognitive Science*, 30(6), 1097-1112.
- Boulenger, V., Hauk, O., & Pulvermüller, F. (2009). Grasping ideas with the motor system: semantic somatotopy in idiom comprehension. *Cerebral cortex*, 19(8), 1905-1914.
- Boulenger, V., Roy, A. C., Paulignan, Y., Deprez, V., Jeannerod, M., & Nazir, T. A. (2006). Cross-talk between language processes and overt motor behavior in the first 200 msec of processing. *Journal of cognitive neuroscience*, 18(10), 1607-1615.
- Boulenger, V., Shtyrov, Y., & Pulvermüller, F. (2012). When do you grasp the idea? MEG evidence for instantaneous idiom understanding. *Neuroimage*, 59(4), 3502-3513.
- Brass, M., Bekkering, H., & Prinz, W. (2001). Movement observation affects movement execution in a simple response task. *Acta psychologica*, 106(1-2), 3-22.
- Buccino, G., Riggio, L., Melli, G., Binkofski, F., Gallese, V., & Rizzolatti, G. (2005). Listening to action-related sentences modulates the activity of the motor system: a combined TMS and behavioral study. *Cognitive Brain Research*, 24(3), 355-363.
- Chersi, F., Thill, S., Ziemke, T., & Borghi, A. M. (2010). Sentence processing: linking language to motor chains. *Frontiers in neurorobotics*, 4, 4.
- Colletta, J. M., Guidetti, M., Capirci, O., Cristilli, C., Demir, O. E., Kunene-Nicolas, R. N., & Levine, S. (2015). Effects of age and language on co-speech gesture production: an investigation of French, American, and Italian children's narratives. *Journal of child language*, 42(1), 122-145.
- De Jorio, A. (2000). *Gesture in Naples and Gesture in Classical Antiquity: a translation of Andrea de Jorio's La mimica degli antichi investigata nel gestire napoletano*. Indiana University Press.
- De Vega, M., Robertson, D. A., Glenberg, A. M., Kaschak, M. P., & Rinck, M. (2004). On doing two things at once: Temporal constraints on actions in language comprehension. *Memory & cognition*, 32(7), 1033-1043.
- Dennison, H. Y., & Bergen, B. K. (2010). Language-driven motor simulation is sensitive to social context. In *Proceedings of the Annual Meeting of the Cognitive Science Society* (Vol. 32, No. 32).
- Desai, R. H., Binder, J. R., Conant, L. L., Mano, Q. R., & Seidenberg, M. S. (2011). The neural career of sensory-motor metaphors. *Journal of cognitive neuroscience*, 23(9), 2376-2386.
- Desai, R. H., Conant, L. L., Binder, J. R., Park, H., & Seidenberg, M. S. (2013). A piece of the action: modulation of sensory-motor regions by action idioms and metaphors. *NeuroImage*, 83, 862-869.
- Diadori, P. (1990). *Senza parole: 100 gesti degli italiani*. Bonacci.

- Efron, D. (1941). *Gesture, race and culture: A tentative study of the spatio-temporal and "linguistic" aspects of the gestural behavior of eastern Jews and southern Italians in New York City, living under similar as well as different environmental conditions* (Vol. 9). Mouton.
- Estes, Z., & Barsalou, L. W. (2018). A comprehensive meta-analysis of spatial interference from linguistic cues: Beyond Petrova et al.(2018). *Psychological science*, 29(9), 1558-1564.
- Estes, Z., Verges, M., & Adelman, J. S. (2015). Words, objects, and locations: Perceptual matching explains spatial interference and facilitation. *Journal of Memory and Language*, 84, 167-189.
- Gianelli, C., & Dalla Volta, R. (2015). Does listening to action-related sentences modulate the activity of the motor system? Replication of a combined TMS and behavioral study. *Frontiers in psychology*, 5, 1511.
- Glenberg, A. M., & Kaschak, M. P. (2002). Grounding language in action. *Psychonomic bulletin & review*, 9(3), 558-565.
- Hauk, O., Johnsrude, I., & Pulvermüller, F. (2004). Somatotopic representation of action words in human motor and premotor cortex. *Neuron*, 41(2), 301-307.
- Henrich, J., Heine, S. J., & Norenzayan, A. (2010). Most people are not WEIRD. *Nature*, 466(7302), 29-29.
- Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world?. *Behavioral and brain sciences*, 33(2-3), 61-83.
- Ji, L. J., Zhang, Z., & Nisbett, R. E. (2004). Is it culture or is it language? Examination of language effects in cross-cultural research on categorization. *Journal of personality and social psychology*, 87(1), 57.
- Kaschak, M. P., Madden, C. J., Theriault, D. J., Yaxley, R. H., Aveyard, M., Blanchard, A. A., & Zwaan, R. A. (2005). Perception of motion affects language processing. *Cognition*, 94(3), B79-B89.
- Kaup, B., Lüdtke, J., & Maienborn, C. (2010). "The drawer is still closed": Simulating past and future actions when processing sentences that describe a state. *Brain and language*, 112(3), 159-166.
- Kendon, A. (2004). Contrasts in Gesticulation. A Neapolitan and a British Speaker Compared. *The Semantics and Pragmatics of Everyday Gestures*. Berlin: Weidler.
- Liepelt, R., Dolk, T., & Prinz, W. (2012). Bidirectional semantic interference between action and speech. *Psychological Research*, 76(4), 446-455.
- Lynott, D., & Connell, L. (2013). Modality exclusivity norms for 400 nouns: The relationship between perceptual experience and surface word form. *Behavior research methods*, 45(2), 516-526.
- Majlisi, M. B. (1986). *Biḥār al-'Anwār al-Jāmi'ah li-Durar 'Akḥbār al-'A'imma al-Aṭḥār* (Vol. 43). Tehran: Dar al-Kotob al-Islamiah.

- 865 Marschark, M., & Wauters, L. (2003). Cognitive functioning in deaf adults and children. *Oxford*
 866 *handbook of deaf studies, language, and education*, 1, 486-99.
- 867
- 868 Miller, J., Brookie, K., Wales, S., Wallace, S., & Kaup, B. (2018). Embodied cognition: Is
 869 activation of the motor cortex essential for understanding action verbs?. *Journal of Experimental*
 870 *Psychology: Learning, Memory, and Cognition*, 44(3), 335.
- 871
- 872 Munari, B., & Saglietti, I. (1994). *Il dizionario dei gesti italiani*. Adnkronos.
- 873
- 874 Nisbett, R. E., & Masuda, T. (2003). Culture and point of view. *Proceedings of the National*
 875 *Academy of Sciences*, 100(19), 11163-11170.
- 876
- 877 Oliveri, M., Finocchiaro, C., Shapiro, K., Gangitano, M., Caramazza, A., & Pascual-Leone, A.
 878 (2004). All talk and no action: a transcranial magnetic stimulation study of motor cortex activation
 879 during action word production. *Journal of cognitive neuroscience*, 16(3), 374-381.
- 880
- 881 Paivio, A. (1986). Psychological processes in the comprehension of metaphor. *Metaphor And*
 882 *Thought*, 163.
- 883
- 884 Paivio, A. (1990). *Mental representations: A dual coding approach* (Vol. 9). Oxford University
 885 Press.
- 886
- 887 Papesh, M. H. (2015). Just out of reach: On the reliability of the action-sentence compatibility
 888 effect. *Journal of Experimental Psychology: General*, 144(6), e116.
- 889
- 890 Pettenati, P., Sekine, K., Congestrì, E., & Volterra, V. (2012). A comparative study on
 891 representational gestures in Italian and Japanese children. *Journal of Nonverbal Behavior*, 36(2),
 892 149-164.
- 893 Ponari, M., Norbury, C. F., & Vigliocco, G. (2017). How do children process abstract concepts?
 894 Evidence from a lexical decision task. *Developmental Science*, 10, 10-11.
- 895
- 896 Pulvermüller, F., Härle, M., & Hummel, F. (2001). Walking or talking?: Behavioral and
 897 neurophysiological correlates of action verb processing. *Brain and language*, 78(2), 143-168.
- 898
- 899 Raposo, A., Moss, H. E., Stamatakis, E. A., & Tyler, L. K. (2009). Modulation of motor and
 900 premotor cortices by actions, action words and action sentences. *Neuropsychologia*, 47(2), 388-396.
- 901
- 902 Sakreida, K., Scorolli, C., Menz, M. M., Heim, S., Borghi, A. M., & Binkofski, F. (2013). Are
 903 abstract action words embodied? An fMRI investigation at the interface between language and
 904 motor cognition. *Frontiers in human neuroscience*, 7, 125.
- 905
- 906 Sato, M., Mengarelli, M., Riggio, L., Gallese, V., & Buccino, G. (2008). Task related modulation of
 907 the motor system during language processing. *Brain and language*, 105(2), 83-90.
- 908
- 909 Savani, K., Markus, H. R., & Conner, A. L. (2008). Let your preference be your guide? Preferences
 910 and choices are more tightly linked for North Americans than for Indians. *Journal of personality*
 911 *and social psychology*, 95(4), 861.
- 912
- 913 Saygin, A. P., McCullough, S., Alac, M., & Emmorey, K. (2010). Modulation of BOLD response in
 914 motion-sensitive lateral temporal cortex by real and fictive motion sentences. *Journal of cognitive*
 915 *neuroscience*, 22(11), 2480-2490.

- Schwanenflugel, P. J., & Stowe, R. W. (1989). Context availability and the processing of abstract and concrete words in sentences. *Reading Research Quarterly*, 114-126.
- Scorolli, C., & Borghi, A. M. (2007). Sentence comprehension and action: Effector specific modulation of the motor system. *Brain research*, 1130, 119-124.
- Scorolli, C., Binkofski, F., Buccino, G., Nicoletti, R., Riggio, L., & Borghi, A. M. (2011). Abstract and concrete sentences, embodiment, and languages. *Frontiers in Psychology*, 2, 227.
- Scorolli, C., Jacquet, P. O., Binkofski, F., Nicoletti, R., Tessari, A., & Borghi, A. M. (2012). Abstract and concrete phrases processing differentially modulates cortico-spinal excitability. *Brain research*, 1488, 60-71.
- Seyed-Gohrab, A. A. (2012). Introduction: Persian rhetorical figures. In *Metaphor and Imagery in Persian Poetry* (pp. 1-13). Brill.
- Tettamanti, M., Buccino, G., Saccuman, M. C., Gallese, V., Danna, M., Scifo, P., ... & Perani, D. (2005). Listening to action-related sentences activates fronto-parietal motor circuits. *Journal of cognitive neuroscience*, 17(2), 273-281.
- Tillotson, S. M., Siakaluk, P. D., & Pexman, P. M. (2008). Body—object interaction ratings for 1,618 monosyllabic nouns. *Behavior Research Methods*, 40(4), 1075-1078.
- Villani, C. A. T. E. R. I. N. A., Lugli, L. U. I. S. A., Liuzza, M. T., & Borghi, A. M. (2019). Different kinds of abstract concept. *Sist. Intell*, 31.
- Zandpour, F. (1996). Personal Relationships in Iran: A Comparative Analysis. *Communication in personal relationships across cultures*, 174.
- Wallentin, M., Østergaard, S., Lund, T. E., Østergaard, L., & Roepstorff, A. (2005). Concrete spatial language: See what I mean?. *Brain and language*, 92(3), 221-233.