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How action and context priming influence categorization: a developmental study

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Abstract

Embodied views of cognition propose that concepts are grounded in sensorimotor experience. Diverse aspects of sensorimotor experience, like action and context information, could play a key role in the formation and processing of manipulable object concepts. Specifically, contextual information could help to link specific actions experienced with different object exemplars. In this study, the effects of action and context priming on superordinate and basic-level categorization of manipulable objects were directly contrasted in 7- and 9-year-olds and in adults. Across the ages, results revealed a differential effect of hand and scene primes on conceptual processing at the superordinate and basic levels; the disadvantage of superordinate over basic-level categorization was reduced in the context priming condition in comparison to the action priming condition. The nature and role of contextual knowledge are discussed from a cognitive and a neurophysiological point of view. Directions for further developmental research on concepts are also considered.

Introduction

Embodied views of cognition (Barsalou, 1999, 2008; Borghi, 2005; Gallese & Lakoff, 2005) propose that concepts and words are grounded in sensorimotor experience. In the case of manipulable objects, concepts would imply the re-enactment of the motor neural pattern activated when interacting with the corresponding objects. These approaches have already received strong experimental support (Borghi, 2004; Gentilucci, 2003; Marques, 2006; Pecher, Zeelenberg, & Barsalou, 2003, 2004; Stanfield & Zwaan, 2001; Zwaan, Stanfield, & Yaxley, 2002) and appear in line with recent neurophysiological evidence regarding the capacity of the human motor system (for a review, see Rizzolatti & Craighero, 2004). Neurons of the premotor cortex can be directly recruited during the visual presentation of an object (canonical neurons) or during the presentation of actions performed by others (mirror neurons). Indeed, the passive vision of manipulable objects (Chao & Martin, 2000; Creem-Regehr & Lee, 2005; Grafton, Fadiga, Arbib, & Rizzolatti, 1997) and the semantic processing of tools (Boronat et al., 2005; Kellenbach, Brett, & Patterson, 2003) as well as the observation of actions (Buccino et al., 2001; Buccino et al., 2004) activate premotor and parietal cortices.

Behavioural findings confirm the fact that action information is an integral part of manipulable object concepts. First, manipulable objects seem to automatically activate motor information. Semantic decisions on objects (e.g., piano) are faster when participants are previously presented with an object of the same kind of manipulation (e.g., typewriter) (Myung, Blumstein, & Sedivy, 2006). Tucker and Ellis (Ellis & Tucker, 2000; Tucker & Ellis, 2004) also reported affordance compatibility effects for manipulable objects. Participants were asked to categorize pictures of manipulable objects into natural kinds or artefacts using 2 keys of a response device mimicking 2 different grasping hand postures, a power and a precision grip, respectively. A power grip involves the whole hand with the thumb opposed to the other fingers while a precision grip leads to grasp an object between thumb and index. Shorter reaction times were observed when the response grip was congruent with the action afforded by the presented object.

Furthermore, hand priming studies suggest that the presentation of action cues induce motor resonance and influence object categorization. Craighero, Bello, Fadiga and Rizzolatti (2002) instructed participants to grasp a bar oriented either clockwise or counterclockwise as quickly as possible in response to visual stimuli. Stimuli were pictures of the right hand executing a grasping action in various orientations. Participants performed a go/no-go task in response to target hand pictures. Reaction times were faster when the position depicted by the hand prime fit the grasping hand final position. These findings demonstrated that, after a motor preparation task, static hand primes could induce a motor simulation. The study by Borghi and colleagues (2007) goes further and revealed that the motor resonance induced by static action primes could help object categorization. In this study, participants were asked to categorize pictures of objects that could be manipulated either with a power or a precision grip into artefacts or natural kinds. Object pictures were primed by the picture of a hand mimicking either a power or a precision grip, which had been previously associated with the corresponding action. Shorter reaction times were reported when the hand prime was congruent with the kind of grip required by the object. Taken as a whole, these results show that visual representation of both objects and actions activate motor information.

Indirect support of embodied views of concepts comes also from evidence of the “instantiation principle”(Borghi & Caramelli, 2003; De Wilde, Vanoverberghe, Storms, & De Boeck, 2003; Heit & Barsalou, 1996; Marques, 2007). According to this principle, superordinate level concepts (e.g., animal) would activate a collection of their exemplars (e.g., dog, cow, horse, etc.) which, in turn, indirectly activate perceptual and action-based information. In a property generation task, Borghi and Caramelli (2001) found, for example, that superordinate level concepts elicited the exemplars of the category more frequently than lower level concepts. Processing superordinate concepts would boil down to processing collections of instances. In general, literature regarding the use of gestures suggest that action information associated with instances during the acquisition of concepts would help the retrieval of conceptual knowledge (Cook, Mitchell, & Goldin-Meadow, 2008; Krauss, 1998). More specifically, studies on the instantiation principle suggest that the role of action would favour retrieval of conceptual knowledge more strongly at the basic-level than at the superordinate level. Thus, grounding concepts in sensori-motor experience could also explain why superordinate concepts are often considered more difficult than basic-level ones (Barsalou, 1999). Furthermore, superordinate concepts (e.g., animal) would not be more "abstract" than basic-level concepts (Barsalou, 2005), since they convey sensorimotor information related to the basic-level concepts they elicit (e.g. dog, cow).

Considering the fact that superordinate level concepts activate a collection of instances, they should also convey information relative to the context in which exemplars are embedded. Contextual information would thus facilitate the access to superordinate level concepts, and reduce the basic-level superiority (Lin, Murphy, & Shoben, 1997). Several studies have provided evidence in this direction. Murphy and Wisniewsky (1989) have shown that the presentation of objects in inappropriate scenes affect categorization performances more frequently when participants have to categorize objects at the superordinate level than at the basic level. Borghi, Caramelli and Setti (2005) found with a priming task and with a feature generation task that superordinate level concepts (e.g., food) were more likely to be associated with scene-like locations (e.g., kitchen), where more exemplars could coexist, whereas basic level concepts (e.g., steak) were more linked to object-like locations, i.e. to containers or supports (e.g., pan), where typically single exemplars are present. When adults process concepts at the superordinate level, they evoke the context in which they have experienced the exemplars of the collection.

These findings appear consistent with the literature on category formation. Several authors argue that concepts are contextualized, namely, that they are closely linked to action events and knowledge of scenes (Mandler, 2000; Nelson, 1983, 1985) throughout life. Thematic relations between objects (e.g., spoon-yoghurt), that refer to contextual relations linking objects of a same action event, are known to be the preferential mode of categorization in young children (Lucariello, Kyratzis, & Nelson, 1992; Smiley & Brown, 1979), but are still easily available in older children and adults (Greenfield & Scott, 1986; Lin & Murphy, 2001; Murphy, 2001). Thus, in line with embodied theories, there is no shift from thematic organization (e.g., tea, bowl, bread) to taxonomic organization (e.g., tea, coffee, milk). Categorization behaviours appear instead to be flexible in both children and adults (Blaye & Bonthoux, 2001; Hashimoto, McGregor, & Graham, 2007; Nguyen, 2007; Nguyen & Murphy, 2003), depending on individuals and situations (Bonthoux & Kalénine, 2007; Kalénine & Bonthoux, 2006). Thematic relations are relevant at all ages, especially for manipulable object concepts (Kalénine & Bonthoux, 2008).

Recently, the specific role of action information in children's conceptual processing has been investigated by Mounoud, Duscherer, Moy and Perraudin (2007) in a developmental study. These authors showed that from 5 years of age until adulthood, action priming facilitates the recognition and categorization of tools. Participants were presented with an action pantomime, followed by a tool photograph. The action depicted in the short movie could be congruent or not congruent with the target object. Participants performed a naming task in experiment 1 and a superordinate categorization task (is it a "do-it-yourself" tool?) in experiment 2. Both experiments revealed facilitation effects. In addition, a developmental trend was observed, with larger priming effects in the youngest groups. Interestingly, facilitation effects were also globally larger in the naming task than in the categorization task. Results suggest that a) from childhood to adulthood, the conceptual processing of a manipulable object is facilitated by the previous activation of its corresponding action, b) this effect is particularly strong during the phases of acquisition of conceptual knowledge and c) action may more directly help to access concepts at the basic-level (naming task) than at the superordinate level (categorization task), which is consistent with the "instantiation principle" (De Wilde et al., 2003; Heit & Barsalou, 1996).

Overall, previous findings show that sensorimotor experience influences conceptual processing, particularly for manipulable concepts for which action knowledge is crucial. Both visually presented objects and actions (e.g, hand primes) activate motor information. In addition, the involvement of action-based knowledge in concepts appears relevant at all hierarchical levels (basic-level and superordinate) and at all ages. Consequently, it would be more difficult to access superordinate level-concepts than basic-level concepts since the former activate action information more indirectly, via the multiple exemplars of the collection. The greater difficulty of superordinate concepts over basic-level ones has been demonstrated in several studies in young children (Mervis & Crisafi, 1982; Mervis & Rosch, 1981). Furthermore, contextual information could help to bind action events activated by different exemplars and thus be particularly relevant when processing concepts at the superordinate level.

The present experiment was designed to assess the relative role of action and contextual information in concepts in children and adults with a priming paradigm. Given that previous studies have demonstrated that both action and contextual information could help children and adults' categorization of manipulable objects, we designed an experiment that directly compares the relative influence of these two kinds of information. To our knowledge, prime pictures activating different aspects of sensorimotor experience, such as action and context, have never been directly contrasted. In addition, in a developmental perspective, the priming task was designed in order to be appropriate to young children as well as to adults. The effects of action and context priming on superordinate and basic-level categorization of manipulable objects were directly contrasted in 7- and 9-year-olds and in adults. We expected an advantage of basic-level over superordinate-level categorization, especially in young children. More crucially, we predicted that the advantage of basic-level over superordinate categorization would be lower in the context priming condition than in the action priming condition.

Method

Participants

Three age groups were considered. The participants were twenty 7 year-old children (M = 7 years 5 months; SD = 5 months), 10 males and 10 females, twenty 9 year-olds (M = 9 years 5 months; SD = 5 months), 9 males and 11 females, and 20 adults (M = 21 years; SD = 3 years 6 months), 2 males and 18 females. The children were attending the second and fourth grade of elementary school, respectively. The adults were psychology students at Pierre Mendes France University (Grenoble, France). They were recruited from announcements within the University, gave oral consent after receiving information about the aim of the study and received course credit for their participation. Ten additional 5-6 year-old children and 10 additional adults were also recruited to control the materials. All participants were French native speakers, naïve to the purpose of the study and had normal or corrected-to-normal visual acuity.

Materials

Black and white photographs were used for prime and target pictures. Oral questions were used for the categorization tasks on target pictures.

Primes were either scenes (spatial context priming condition) or hands (hand priming condition). The scenes represented either an inside environment, i.e. a living room, or an outside environment, i.e. a garden. Pictures of hands were human right hands mimicking either a precision or a power grip. They were displayed on a complex geometric background in order to equalize visual complexity with scene primes. This geometric background was selected among 4 potential geometric backgrounds during a pre-test. We asked 10 adults to rate the visual complexity of 10 pictures on a 7-point scale. The 10 pictures included the precision and power grip hands presented on 4 different geometric backgrounds and the inside and outside scenes. We selected the hand pictures that were judged the most similar to the scenes in term of visual complexity for the test. An additional scene, i.e. a seaside, and an additional hand posture, i.e. an open hand displayed on the geometric background, were also designed for catch-trials. The size of prime pictures was 20 x 15 cm in the 2 priming conditions.

Targets consisted in pictures of manipulable objects, both natural kinds and artefacts. They were selected according to object manipulability, age of acquisition of object basic-level and superordinate names, object context and familiarity with object manipulation. First, only objects that could be used with 1 hand were selected. Then, the age of acquisition of target basic-level names were checked so that all nouns were acquired before age 7 according to French norms (Cannard, Blaye, Scheuner, & Bonthoux, 2005). Target objects also belonged to well-defined superordinate categories: fruit, plants, tools, kitchen utensils, school stationary, clothes, games and jewels. Superordinate names were all acquired before 7 years of age with the exception of kitchen utensils and school stationary. For these categories we used more familiar wording, commonly used in French (“*affaires”)*. In addition, we ensured that children from 7 years of age on actually know the way of manipulation of objects even if they have not already used these objects by themselves (e.g., objects such as a saw). To do this, an additional group of 10 younger children (5-6 year-olds) was asked to mimic the use of objects from their names. Only objects that received correct mimes from the 10 children were considered. Half of the target objects would be found in the inside scene and half would be found in the outside scene. Target objects of each spatial context could be manipulated with either a power or a precision grip in equivalent proportions. Note also that the shape (elongated versus round) and the position of the grip part (left versus right) of the target objects were controlled. There were as many elongated as round objects and as many left-oriented as right-oriented target pictures designed for each context and each grip. Twelve test targets (table 1) and 10 additional targets (fillers and practice trials) were designed following these criteria. They were 15 x 15 cm and were displayed on a plain white background.

Oral questions for the basic-level and superordinate categorization tasks were recorded by a French speaker and followed the form “a kind of __?”, with the exception of kitchen utensils and school stationary, for which the word “*affaire*” was used instead of “kind”. In the superordinate task, the name corresponded to the category name (e.g., fruit, tool). In the basic-level task, the name corresponded to the exemplar name (e.g., orange, saw). Duration of questions ranged from 1000 to 1450 ms. During the task, questions were heard from the computer by the participants.

[Please insert Table 1 about here]

Procedure

Participants sat in front of a computer monitor. Trials were displayed using the E-prime software (E-prime Psychology Software Tools Inc., Pittsburgh, USA). Each trial began with a fixation point for 500 ms. Then the prime (scene or hand) was displayed for 500ms immediately followed by the target picture. The oral question (i.e. “a kind of __?”) began 500ms after the presentation of the target picture. The target picture remained on the screen during the duration of the oral question until participants’ response (Figure 1). Participants had to respond “yes” or “no” to the categorization question as quickly and accurately as possible using 2 designated keys. Participants of each age group performed either the superordinate categorization task or the basic-level task. They were randomly assigned to one of the two task groups. There was the same number of participants in each task group. To avoid a potential compatibility effect between the hand prime and the response hand, half participants were asked to respond “yes” with their right hand, and half were asked to respond “yes” with their left hand. Accuracy and reaction times were recorded.

[Please insert Figure 1 about here]

The context and the hand priming conditions were performed successively in 2 separate blocks. The order of presentation was strictly counterbalanced between subjects. In each block, half the trials required a “yes” response and half required a “no” response. In the whole experiment, the 12 test target pictures were presented twice with a “yes” response to the same categorization question, once with their corresponding spatial context prime (inside or outside scene) in the context priming condition and once with their corresponding hand prime (power or precision grip) in the hand priming condition. To avoid the formation of potential strategies, “no” trials were composed of 6 test targets coupled with irrelevant questions and 6 filler targets. Targets used for “no” trials also appeared twice, once in the spatial context priming condition and once in the hand priming condition. Moreover, we introduced 3 catch-trials in each condition to ensure that participants paid attention to the prime. The number of catch trials was reduced as much as possible in order to keep the task feasible for the youngest children. When the prime depicted either a seaside in the spatial context priming condition or an open hand in the hand priming condition, participants were instructed to refrain from responding. The procedure was identical for the 2 blocks. Before each block, instructions were provided using a learning trial and the prime picture used for catch trials was presented. Then, participants performed 5 practice trials (including 1 catch-trial) in which they received feedback on the accuracy of their responses. Practice trials were followed by the 24 experimental trials and the 3 catch-trials in a random order, in which participants did not receive any feedback. The whole experiment consisted of 48 experimental trials.

Results

Statistical analyses were conducted on correct reaction times for the 24 experimental trials requiring a “yes” response (Table 2). Catch-trials and “no” response trials were considered fillers and were not analyzed. However, we checked that participants correctly performed the task on catch trials. For these trials, an error corresponded to a response, whether it was correct or not. No participants made more than 1 error out of 3 on catch trials in each priming condition, hence indicating that they did process the primes. Errors on “yes” experimental trials accounted for 6% of responses. Outliers in the data set were identified using Studentized Deleted Residuals (SDR). We used a simple linear regression model in which each reaction time was predicted by the mean reaction time of the participant in the corresponding experimental condition. Observations that obtained a SDR value > 3.5 were removed from the analysis and accounted for 1.3% of the whole data set. Analysis was done after logarithmic transformation to ensure distribution normality and variance homogeneity across all conditions.

A 4-way Anova with Age (7 year-olds, 9 year-olds, adults), Task (superordinate level, basic-level) and Order of Condition (context-hand, hand-context) as between-subject factors, and Priming Condition (context, hand) as within-subject factor was conducted on correct reaction times. Note that the Order of Condition was not a factor of interest but was introduced in the experimental design since a learning effect could easily be expected in the second block condition (either context or hand priming). Indeed, there was an effect of the Order of Condition, with shorter reaction times in the second block [$F(1,48) = 64.01$; $p < .001$]. However, this effect was neutralized by strictly counterbalancing the Order of Condition (context vs. hand priming) between subjects in each task group (superordinate level vs. basic-level).

[Please insert Table 2 about here]

Main effects of Age [$F(2,48) = 38.47$; $p < .001$; $\eta^2 = .62$] and Task [$F(1,48) = 12.89$; $p < .001$; $\eta^2 = .21$] were observed. Planned comparisons showed that adults were faster than children [$F(1,48) = 61.19$; $p < .001$] and that 9 year-olds were faster than 7 year-olds [$F(1,48) = 15.76$; $p< .001$]. Categorization was also faster at the basic level than at the superordinate level [$F(1,48) = 12.89$; $p < .001$]. In addition, the effect of Task was modulated by Age [$F(2,48) = 4.54$; $p < .05$; $\eta^2 = .16$]. A Tukey post-hoc test indicated that this Task x Age interaction was due to the existence of a basic-level advantage in 7 year-olds and in adults ($p <.05$) but not in 9 year-olds ($p = .99$). More importantly, the predicted interaction between Task and Priming Condition was significant [$F(1,48) = 4.93$; $p < .05$; $\eta^2 = .09$]: irrespective of age, the advantage of the basic-level task over the superordinate-level task was greater in the hand priming condition than in the context priming condition. Since the 3-way interaction between Age, Task and Priming Condition was not significant [$F(2,48) = 2.07$; $p = .14$], the modulation of the effect of the categorization level (Task) by the type of prime (Priming Condition) was not statically different between age groups. We nevertheless tested the significance of the Task x Priming Condition interaction separately in each age group (Figure 2). The interaction was only significant in 7 year-olds [$F(1,48) = 7.24$; $p < .01$ in 7 year-olds, $F(1,48) <1$ in 9 year-olds and $F(1,48) =1.80$; $p = .18$ in adults]. However, the pattern observed in adults was very similar to the one observed in 7 year-olds.

A similar 4-way Anova conducted on correct responses did not show any evidence of a speed-accuracy trade-off in participants' performance. Moreover, the main effects of Age and Task were also significant, confirming that overall participants' accuracy improved with age [$F(1,48) = 9.62$; $p < .001$] and was greater in the basic level task than in the superordinate level task [$F(1,48) = 4.16$; $p <.05$].

[Please insert Figure 2 about here]

Discussion

The findings reported here support embodied views of concept formation, providing new insights into the role of various aspects of sensorimotor knowledge in categorization of manipulable objects by 7 years of age. In keeping with the literature on concept formation, our data confirm that conceptual processing of manipulable objects improved with age. In addition, across the ages, object categorization was faster at the basic-level (e.g. saw) than at the superordinate level (e.g., tool). This result appears consistent with the idea that participants activate a collection of exemplars when processing superordinate concepts.

Binding exemplars of different shapes and other perceptual features related to various action events together would require additional processing and therefore more time. However, when specifically testing the difference between basic-level and superodinate in each age group, we did not find the expected basic-level advantage in 9 year-olds. Even though 9-year-olds were globally faster than 7 year-old children, this result is probably not due to a floor effect (i.e. lowest possible reaction times) in the basic-level task in 9 year-old children. Indeed, adult participants were also globally faster than 9 year-olds and demonstrated a basic-level advantage. One could speculate that this absence of difference between basic-level and superordinate categorization might be linked to specific school training. We know that during elementary school, children receive formal teaching about superordinate categories. All the 9 year-olds tested in this experiment attended the same teaching class. It is therefore possible that recent formal learning of superordinate categories would have facilitated superordinate-level categorization and reduced the basic-level advantage. This may have made superordinate concepts temporarily more accessible.

Our crucial finding concerns the differential effect of action and context priming on basic-level and superordinate conceptual processing. Results showed that across the ages, contextual priming (i.e. the photo of a scene) reduced the disadvantage of superordinate over basic-level categorization in comparison with action priming (i.e. the photo of a hand in a grasping posture). Again, when specifically testing the interaction between the priming condition and the categorization level in each age group, it was only present in 7 year-olds. However, the non-significant pattern observed in adults was similar to the one obtained in 7 year-olds. Thus, no linear developmental trend (*i.e.* a decrease of the differential effect of context and action priming with age) may be considered. Rather, 9-year-olds might not have benefited from the context prime in the superordinate-level task given that they were not globally disadvantaged in this task in comparison to the basic-level task.

Overall, our findings suggest that by 7 years of age at least, 2 aspects of sensorimotor knowledge, namely the way objects are manipulated and the context in which they are experienced, appear to have different roles in conceptual processing. Hand primes would automatically activate motor information corresponding to the action afforded by manipulable objects and thus facilitate the subsequent processing of these objects. Our findings confirm the assumption stemmed from the results of Mounoud and colleagues (2007). They reported action priming effects on object identification by 5 years of age. Moreoever, the size of their priming effects was far more important in a naming task in Experiment 1 (212 ms) than in a superordinate categorization task in Experiment 2 (59 ms) for similar age groups, even if the 2 experiments could not be directly compared. The findings of the present study, in which a basic-level task and a superordinate-level task were designed in the same experiment, support the interpretation that action priming is indeed more efficient to process a single exemplar than a collection of exemplars.

As far as we know, the issue of the influence of different kinds of sensorimotor information (e.g., context and action) during categorization of objects at basic and superordinate levels has not been addressed. Part of the novelty of our study is that it investigates with a priming paradigm the different role played not only by motor but also by contextual information on basic and superordinate level categorization. Along with evidence on superordinate categorization in adults (Murphy & Wisniewski, 1989), our results clearly show that by 7 years of age, contextual cues help to access superordinate level concepts and thus reduce the basic-level superiority. The context in which objects are experienced would work as glue to link action events encountered with exemplars together. Regarding this finding, the main question that arises is the nature of contextual knowledge. Specifically, what kind of information does the context convey in order to help conceptual processing at the superordinate level? On the one hand, the context refers to visual information. We see the world in scenes, and scenes can be processed very quickly by the visual system (Thorpe, Fize, & Marlot, 1996). Observers can categorize scenes very briefly (< 150 ms) on the basis of the low spatial frequency content in the image (Bullier, 2001; Peyrin, Baciu, Segebarth, & Marendaz, 2004) . Of importance in terms of our aim, there is evidence showing that context facilitates object recognition: visual scenes activate context frames that could therefore activate a collection of exemplars and facilitate their recognition (Bar, 2004). On the other hand, a recent neuroimaging study (Iacoboni et al., 2005) suggests that context does not activate only visual information but that it is also linked to the motor system. Namely, accessing a context can provide the cues to prepare for situated action with the objects embedded within it. Iacoboni and colleagues reported that the observation of both action and context video clips recruited the parieto-frontal circuit for grasping. Context observation did not activate the superior temporal sulcus and the inferior parietal lobule involved in action observation but did activate the inferior frontal areas linked to grasping. This suggests that both canonical and mirror neurons of the premotor cortex are activated during the observation of action, whereas only canonical neurons fire during the observation of context clips. Contextual information, through the recruitment of the canonical neurons, might be helpful to prepare situated actions toward objects. In this perspective, one might speculate that basic-level and superordinate-level manipulable object concepts rely differently on motor information through the recruitment of different populations of neurons, mirror and canonical neurons respectively, even if the existence of a mirror neuron system in children is still questioned (Lepage & Théoret, 2007).

From a developmental point of view, the influence of children's sensorimotor experience in concept formation is a central issue and is also still a matter of debate. Several authors claim that concepts develop from children' naive theories about the world (Inagaki & Hatano, 2004; Keil, 2006; Spelke & Kinzler, 2007). Children would rely on their beliefs about the essential properties of objects (Gelman, 2004), such as the function intended by the creator of the object to categorize them (Kelemen & Carey, 2007). For example, an object would be categorized as a pencil as soon as children believe it has been created to write. According to the essentialist claim, sensori-motor experience is not assumed to drive concept formation. In contrast with this view, the embodied perspective assigns a crucial role to sensori-motor experience. This perspective is supported by an increasing amount of evidence. Perceptual and motor experience has been shown to affect categorization behaviour even in very young children (Gershkoff-Stowe & Rakison, 2005). In an elegant study in 2 year-olds, Smith (2005) revealed that the kind of action performed on an object affects its subsequent categorization. When children have previously moved a round object horizontally (vs. vertically), they tend to categorize the object according to the kind of shape elicited by the movement, i.e. as a horizontally (vs. vertically) elongated object. In our study, the role of sensorimotor experience in concepts has been investigated in 7- and 9 year-olds and in adults. We reported a differential effect of action and context priming on basic-level and superordinate conceptual processing of manipulable objects by 7 years of age. This may provide better understanding of the mechanisms underlying the formation of basic-level and superordinate concepts by 7 years of age. The relevance of the distinction between action and context information in younger children needs further research. This points out the necessity of developing experimental methods adapted to young children that should be sensitive enough to detect such fine distinctions in conceptual processing.

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Figure captions

Table 1: Design of the 12 test target pictures in each priming condition

Table 2: Mean reaction times (standard deviations) in milliseconds to the categorization task for the 12 experimental conditions

Figure 1: Procedure of an experimental trial in the context priming condition (top) and in the hand priming condition (bottom)

Figure 2: Means and standard errors of correct reaction times (in milliseconds) as a function of age, task (categorization level) and priming condition

Table 1: Design of the 12 test target pictures in each priming condition

Context priming	Living room		Garden	
Hand priming	Power grip	Precision grip	Power grip	Precision grip
Target pictures	Bowl Bunch Orange	Pen Puzzle Eraser	Ball Watering can Saw	Cherry Cap Leaf

Table 2: Mean reaction times (standard deviations) in milliseconds to the categorization task for the 12 experimental conditions

Age	7 year-olds		9 year-olds		Adults	
Task (level)	Basic	Sup	Basic	Sup	Basic	Sup
Context Priming	1675 (169)	1983 (321)	1591 (372)	1544 (197)	1179 (159)	1364 (132)
Hand Priming	1614 (263)	2123 (450)	1570 (287)	1530 (253)	1140 (110)	1407 (234)

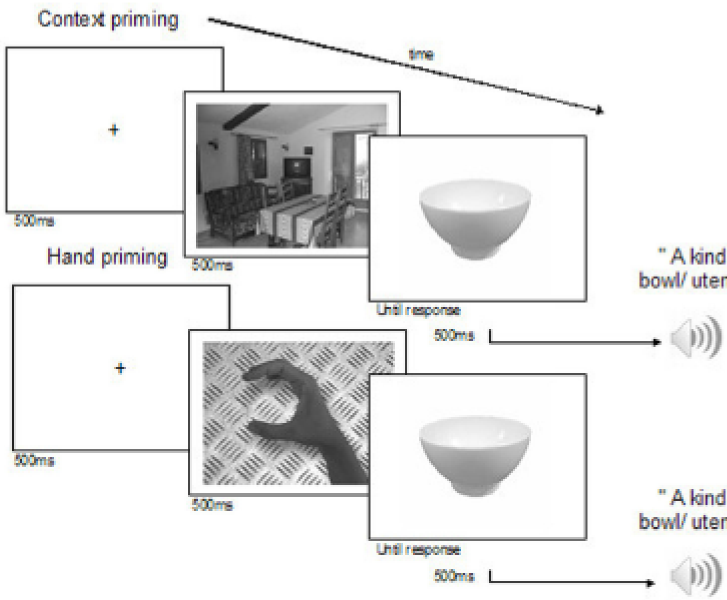
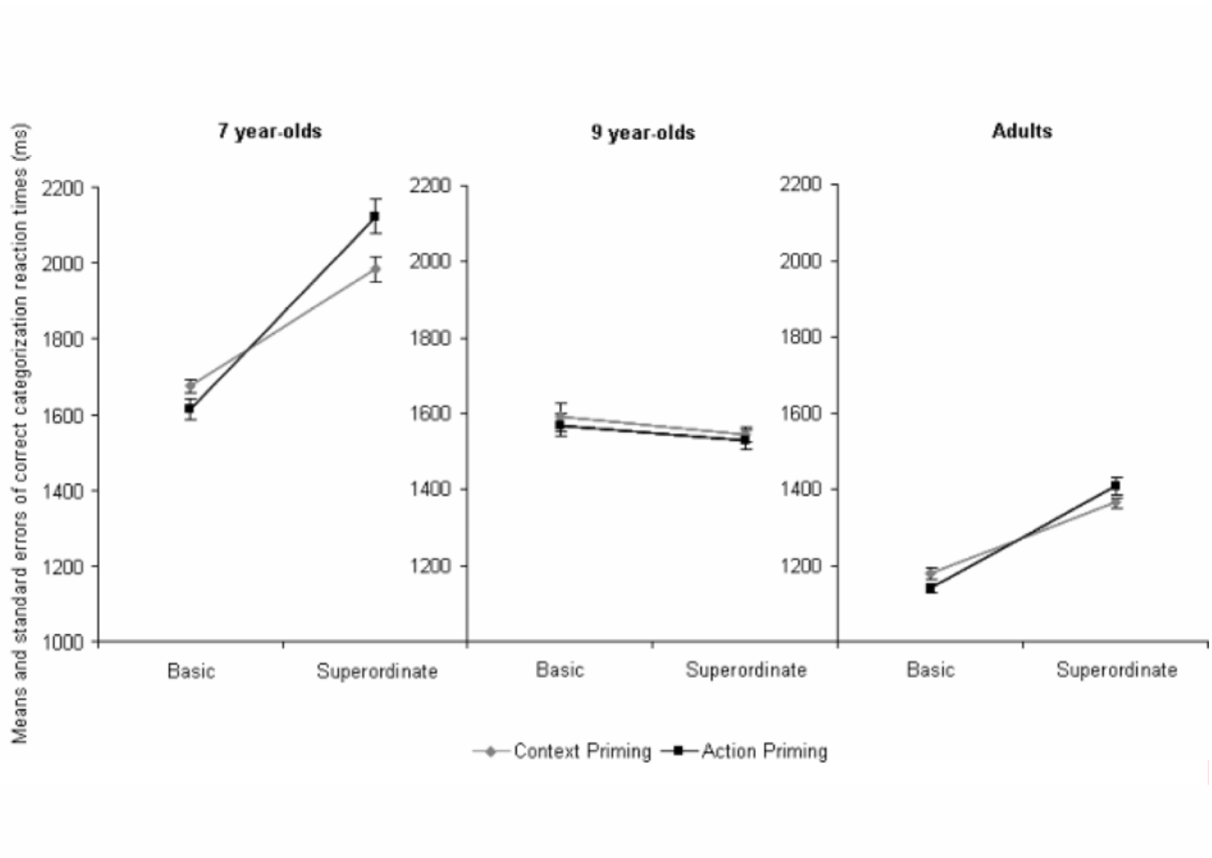


Figure 1: Procedure of an experimental trial in the context priming condition (top) and in the hand priming condition (bottom)



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