

PSYCHONOMIC BULLETIN & REVIEW

Object manipulability affects children and adults' conceptual processing

Journal:	<i>Psychonomic Bulletin & Review</i>
Manuscript ID:	PBR-BR-07-188.R3
Manuscript Type:	Brief Report
Date Submitted by the Author:	07-Jan-2008
Complete List of Authors:	Kalénine, Solène; Laboratoire de Psychologie et Neurocognition Bonthoux, Françoise; Laboratoire de Psychologie et Neurocognition
Keywords:	concepts, categorization, cognitive development, embodied cognition

Final

1
2
3
4
5
6
7
8
9
10
11
12
13
14 **Object manipulability affects children and adults' conceptual processing**
15

16
17
18 **Solène Kalénine, and Françoise Bonthoux**
19

20
21
22
23 Laboratoire de Psychologie et NeuroCognition, CNRS UMR 5105, Université Pierre
24 Mendès France, PO Box 47, F-38040 Grenoble Cedex 9.
25
26
27
28
29
30
31

32 Running head: Manipulability affects conceptual processing by 5 years of age
33
34
35
36
37
38
39
40
41
42

43 Correspondance concerning this article should be sent to Solène Kalénine, Laboratoire de Psychologie et
44 NeuroCognition, CNRS UMR 5105, Université Pierre Mendès France, PO Box 47, F-38040 Grenoble Cedex
45 9, France. Phone: +33 (0)4 76 82 58 60. E-mail: solene.kalenine@upmf-grenoble.fr
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

ABSTRACT

Research on kind concepts indicates that children use perceptual and functional information differently to form natural and artifacts concepts. Beyond object domain, object manipulability appears to be a decisive factor in adult conceptual processing. Thus, the effect of object manipulability on conceptual processing was tested in 5- and 7- year-olds and adults using a picture matching task. Reaction times for identifying conceptual relations based on perceptual similarity (e.g., jacket-coat) and contextual/functional information (e.g., jacket-hanger) were analyzed according to object manipulability and domain. Both children and adults were faster to identify contextual/functional relations for manipulable than for non-manipulable objects. Conversely, they were faster to identify perceptual similarity relations for non-manipulable than for manipulable objects, particularly for natural concepts. Results reveal an early distinction between concepts of manipulable and non-manipulable objects. Implications for further research on concept formation and for embodied views of concepts are discussed.

INTRODUCTION

A large body of evidence from developmental psychology, cognitive psychology and neuropsychology supports the idea that there are different kinds of concepts. Artifact concepts would be mostly characterized by function whereas natural kinds would be predominantly organized around perceptual information. Numerous studies in children show that functional similarities drive induction, name generalization and categorization for artifacts from age two at the latest (Casler & Kelemen, 2007; Diesendruck, Markson, & Bloom, 2003; Kemler Nelson, Chan Egan, & Holt, 2004; Kemler Nelson, Russell, & Jones, 2000; Truxaw, Krasnow, Woods, & German, 2006). On the contrary, children often rely on perceptual similarity to categorize natural kinds (Sloutsky, Kloos, & Fisher, 2007; Sloutsky & Spino, 2004). Moreover, data from properties generation tasks in normal adults (Cree & McRae, 2003; McRae, Cree, Seidenberg, & McNorgan, 2005) and children (Hughes, Woodcock, & Funnell, 2005) demonstrated that perceptual/visual features are more important for natural kinds while contextual/functional features are more crucial for artifacts. This dissociation is also well documented in neuropsychology with reports of semantic deficits specific to natural kinds or artifacts (for a review, see Capitani, Laiacona, Mahon, & Caramazza, 2003). On the whole, these findings indicate that different

1
2
3
4
5
6
7 conceptual mechanisms may underlie natural kinds and artifact concepts, based
8
9 on the detection of perceptual and functional similarities, respectively.
10

11
12 However, the distinction between natural kind and artifact concepts does
13
14 not appear so clear-cut. Recently, the importance of function has also been
15
16 generalized to natural concepts (DiYanni & Kelemen, 2005; Kelemen & DiYanni,
17
18 2005). In the same way, the influence of perceptual similarity does not seem
19
20 restricted to natural kinds and has also been observed for artifacts (Diesendruck &
21
22 Bloom, 2003; Diesendruck, Hammer, & Catz, 2003). As internal and functional
23
24 features usually determine superficial ones (Ahn, Gelman, Amsterlaw,
25
26 Hohenstein, & Kalish, 2000), perceptual properties can heuristically be good cues
27
28 to categorize both natural objects and artifacts. Moreover, category-specific
29
30 deficits in brain-damaged patients do not systematically follow the living/non-
31
32 living dissociation (Capitani et al., 2003). These findings suggest that functional
33
34 and perceptual similarities are important cues for both natural kind and artifact
35
36 concept formation.
37
38
39
40
41

42
43 Furthermore, a finer distinction between manipulable and non-manipulable
44
45 object concepts may be considered in the light of recent work on conceptual
46
47 processing, mainly in adults. Findings from property verification (Borghia, 2004;
48
49 Marques, 2006; Pecher, Zeelenberg, & Barsalou, 2003, 2004) and language
50
51 comprehension (Stanfield & Zwaan, 2001; Zwaan, Stanfield, & Yaxley, 2002)
52
53 seem to indicate that adults re-activate their sensorimotor experience with objects
54
55
56
57
58
59
60

1
2
3
4
5
6 when processing concepts (Barsalou, 1999, 2008). Consequently, manipulable
7 objects would give rise to specific conceptual processing as they strongly involve
8 motor experience. Manipulation priming has been observed for manipulable
9 objects, e.g., “piano” primed “typewriter” (Myung, Blumstein, & Sedivy, 2006).
10
11 Tucker and Ellis (2004) also reported affordance compatibility effects (i.e.,
12 shorter reaction times when the response grip was congruent with the action
13 afforded by the presented object) for manipulable objects, either natural objects or
14 artifacts. In a recent developmental study, Mounoud, Duscherer, Moy and
15 Perraudin (2007) have shown that identification and categorization of tools by 7
16 and 9 year-olds are facilitated by the previous presentation of their corresponding
17 action pantomime. In addition, data from neuroimager y shows that tool
18 conceptual processing specifically activates those cerebral areas involved in
19 object manipulation, i.e., parietal and premotor cortices (Chao & Martin, 2000;
20 Gerlach, Law, & Paulson, 2002; Kellenbach, Brett, & Patterson, 2003). On the
21 contrary, animate concepts mostly activate the visual system, i.e. the temporo-
22 occipital cortex (for a review, see Martin, 2007). Moreover, manipulability could
23 be a confounded factor when comparing natural (e.g., animals) and artifacts (e.g.,
24 tools/household items) concepts. Filliter, McMullen, and Westwood (2005)
25 demonstrated that when object domain and object manipulability were
26 specifically dissociated, object identification speed depended on object
27 manipulability. Thus, while object manipulability appears to be a decisive factor
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7 in adult conceptual processing, the distinction between manipulable on non-
8
9 manipulable objects has never been explored in research on conceptual
10
11 development.

12
13 The present study was designed to test a distinction between manipulable
14
15 and non-manipulable object concepts in children. We investigated how children
16
17 process perceptual/visual and contextual/functional similarities for manipulable
18
19 and non-manipulable objects, both natural kinds and artifacts. We used basic-level
20
21 taxonomic (e.g., jacket-coat) and thematic relations (e.g., jacket-hanger) between
22
23 representations of real objects. These relations a) are mainly based on perceptual
24
25 similarity and contextual/functional relations, b) can be directly detected from the
26
27 environment from an early age and c) concern all kinds of objects. We expected
28
29 that children would be faster to process basic-level relations (perceptual/visual
30
31 similarity) for non-manipulable than for manipulable objects. Conversely, we
32
33 assumed that children would be faster to process thematic relations
34
35 (contextual/functional similarity) for manipulable than for non-manipulable
36
37 objects.
38
39
40
41
42
43
44
45
46
47

48 METHOD

49 50 51 52 Participants

1
2
3
4
5
6
7 In a developmental perspective, three age groups were considered. Thirty-
8 six 5 year-old children ($M = 5$ years 6 months; $SD = 3$ months), 22 girls and 14
9 boys, and thirty-six 7 year-old children ($M = 7$ years 6 months; $SD = 4$ months),
10 16 girls and 20 boys, participated in the study. Children attended preschool and
11 second year of elementary school, respectively. Twenty adults ($M = 23$ years 6
12 months; $SD = 7$ years 2 months) were also recruited. They were psychology
13 students from the University Pierre Mendès France and they received course
14 credit for their participation.
15
16
17
18
19
20
21
22
23
24

25 26 27 28 Materials

29
30 Test stimuli were 100 black-and-white drawings including 20 target
31 pictures. Manipulability and domain were crossed between target pictures: 5
32 represented manipulable artifacts (tools, kitchen utensils, and clothes), 5
33 manipulable natural objects (fruits, vegetables, plants, and body parts), 5
34 non-manipulable artifacts (habitat, furniture, and vehicles) and 5 non-manipulable
35 natural objects (animals and human beings). Manipulable objects were objects
36 that could be picked up or grasped with the hand in relation with their intended
37 use. For each target picture (e.g., jacket), four other pictures were selected. One
38 was taxonomically related at the basic-level (e.g., coat) and one thematically
39 related (e.g., hanger); the other two were non-related to the target picture (e.g.,
40 stove and hot-air balloon). Forty test triads including a target picture, a related
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

picture (either thematically or taxonomically related) and a non related-picture were designed (Figure 1 and Appendix).

Control of perceptual similarity

Basic-level taxonomically related pictures were expected to be more visually similar than thematically related pictures. However, within each type of relation, perceptual similarity should be equivalent between the 4 object kinds (manipulable-non manipulable x artifact-natural). To ensure that it was the case, the 40 related picture pairs were presented one at a time to 20 additional adults. They were instructed to rate, for each pair, to what extent the 2 pictures were visually similar on a 10-points scale. The ANOVA conducted on mean visual similarity scores with Relation Type, Object Manipulability and Object Domain as between-items factors only revealed a main effect of Relation Type. Basic-level taxonomic relations ($M = 6.6$, $SD = 1.43$) were more similar than thematic relations ($M = 2.2$, $SD = 0.82$) [$F(1,32) = 144.5$, $p < .001$].

Control of thematic associative strength

Thematically related pictures were designed to be highly associated at any age. In addition, the associative strength between the target pictures and their thematically related pictures should not differ between the 4 object kinds. A mean measure of associative strength for each thematic pair was obtained for each age group. Ten additional 5 year-olds, 7 year-olds and adults were presented the 20 critical thematic pairs with 20 fillers (more or less associated), one pair at a time.

1
2
3
4
5
6
7 They were instructed to rate on a 10-points scale how strongly the 2 pictures were
8 associated. For children, we used manual scales very similar to those used to
9 measure pain intensity (McCaffery & Beebe, 1993). Separate ANOVAs were
10 conducted in each age group on the mean associative strength score with Object
11 Manipulability and Object Domain as between-items factors. No effect was
12 significant, confirming that the associative strength between thematic related
13 pictures was equivalent between object conditions. They were all highly
14 associated (5 year-olds: $M = 8.64$, $SD = 1.24$; 7 year-olds: $M = 8.31$, $SD = 1.20$;
15 adults: $M = 8.85$, $SD = .085$).
16
17
18
19
20
21
22
23
24
25
26
27
28
29

30 The 40 triads were displayed in two series of 20 trials. Each target picture
31 appeared twice, with a basic-level taxonomic associate in one list and with a
32 thematic associate in the other. Eight additional triads were designed as practice
33 trials.
34
35
36
37
38
39
40
41

42 [Figure 1 about here]
43
44
45
46
47

48 Procedure

49 Triads were displayed on a computer monitor using the E-prime software
50 (E-prime Psychology Software Tools Inc., Pittsburgh, USA). Each trial began
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

with a fixation point for 500 ms. It was immediately followed by the display of a triad composed of one target picture, one related picture and one non-related picture. Each target picture appeared in center of the top of the screen. The related and non-related pictures were presented either in the bottom left or bottom right corner of the screen, their relative position being counterbalanced across trials. Participants were asked to decide "which one of the two bottom pictures *goes with* the target picture" using the two buttons of the response box. They were instructed to press the left button with their left index for the bottom left picture and the right button with their right index for the bottom right picture. They were told to respond as quickly and accurately as possible. Each triad was displayed until the participant responded. Each participant performed 8 practice trials and then performed the task with the two lists of 20 trials each. Children could have a break of a few minutes between lists to relax. The order of list presentation was counterbalanced across subjects. Reaction times and accuracy were recorded for the 40 experimental trials.

RESULTS

Because the task was very easy for adults and their reaction times were consistently shorter than children's, separate statistical analyses were conducted. Response times that were more than three standard deviations above of each

1
2
3
4
5
6
7 participant's mean (1.5 % of children's and adults' data), as well as reaction times
8
9 for incorrect responses (4.5 % of children's data and 1.3 % of adults' data) were
10
11 excluded from the analysis. This trimming method led to the removal of 6 % of
12
13 the data at the most. Analysis on correct reaction times was done after a
14
15 logarithmic transformation. Normality of distributions and homogeneity of
16
17 variances across conditions were thus respected. Results are reported on Figure 2.
18
19

20
21
22
23 [Figure 2 about here]
24
25
26

27 Analysis of children's performance

28
29 A 4-way ANOVA with Relation Type (basic-level taxonomic, thematic),
30
31 Object Manipulability (manipulable, non-manipulable) and Object Domain
32
33 (natural kinds, artifacts) as within-subject factors and Age (5 and 7 years) as a
34
35 between-subjects factor was conducted on correct reaction times. The main
36
37 effects of Age, Relation Type, Object Manipulability and Object Domain were
38
39 significant. Older children were faster than younger ones [$F(1,70) = 57.57, p <$
40
41 $.001$]. Moreover, a global advantage was observed for basic-level taxonomic
42
43 relations [$F(1,70) = 105, p < .001$], for non-manipulable objects [$F(1,70) = 18.7,$
44
45 $p < .001$], and for natural kinds [$F(1,70) = 5.37, p < .05$]. More importantly, the
46
47 expected interaction between Relation Type and Manipulability was significant
48
49 [$F(1,70) = 37.11, p < .001$]. Planned comparisons revealed that children were
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

faster to identify thematic relations for manipulable objects ($M = 2445$ ms, $SD = 770$ ms) than for non-manipulable objects ($M = 2527$ ms, $SD = 757$ ms) whatever the domain the objects belonged to [$F(1,70) = 5.78$, $p < .05$]. On the contrary, children accessed basic-level taxonomic relations for non-manipulable objects ($M = 2059$ ms, $SD = 761$ ms) more quickly than for manipulable objects ($M = 2276$ ms, $SD = 714$ ms), [$F(1,70) = 49.93$, $p < .001$]. Moreover, the interaction between Relation Type and Object Manipulability was modulated by domain of objects, as indicated by the 3-way Relation Type x Object Manipulability x Object Domain interaction [$F(1,70) = 8.24$, $p < .01$]. Scheffe post-hoc test revealed that for basic-level taxonomic relations, the disadvantage for manipulable objects was greater in the case of natural kinds [$p < .005$]. The pattern of results was similar between the 5 and 7 year-olds since Age did not interact with any of the within-subject factors.

Concerning accuracy, mean error rate was relatively low ($M = 6\%$) even in the youngest group ($M = 9\%$). Nevertheless, to ensure that there was no speed-accuracy trade-off, a 4-way ANOVA on accuracy performance was performed. Results show significant main effects of Age and Relation Type consistent with reaction times. A global advantage was observed for older children and for basic-level taxonomic relations. However, object manipulability did not influence accuracy. This result confirms the absence of speed-accuracy trade-off in children's performance.

Analysis of adult performance

Since errors performed by adults were very rare ($m = 1.3\%$), they were not analyzed. A 3-way Anova with Relation Type (basic-level taxonomic, thematic), Object Manipulability (manipulable, non-manipulable) and Object Domain (natural kinds, artifacts) as within-subject factors conducted on correct reaction times revealed similar effects as in children. There was a main advantage for basic-level taxonomic relations [$F(1,19) = 120.3, p < .001$]. The predicted interaction between Relation Type and Object Manipulability was significant [$F(1,19) = 60.57, p < .001$] and was modulated by Object Domain as indicated by the 3-way Relation Type x Object Manipulability x Object Domain interaction [$F(1,19) = 9.33, p < .01$]. Like children, adults identified thematic relations faster for manipulable ($M = 1207$ ms, $SD = 274$ ms) than for non-manipulable objects ($M = 1307$ ms, $SD = 309$ ms), [$F(1,19) = 16.64, p < .001$]. They also identified basic-level taxonomic relations faster for non-manipulable ($M = 973$ ms, $SD = 169$ ms) than for manipulable objects ($M = 1087$ ms, $SD = 230$ ms), [$F(1,19) = 61.68, p < .001$]; again this difference was greater for natural objects as indicated by a Scheffe post-hoc test [$p < .005$].

DISCUSSION

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

The present findings provide initial evidence for the influence of object manipulability on children's conceptual processing. Five and seven year-old children, like adults, processed perceptual similarity and contextual/functional relations differently for manipulable and non-manipulable object concepts.

Thematic relations processing was faster for manipulable than non-manipulable objects independently of domain (natural kinds or artifacts). Thematic relations (e.g., spoon-yoghurt) are based on contextual and functional relations between objects that can be easily detected from interactions with objects in daily action schemas (Borghi & Caramelli, 2003; Mandler, 2000; Nelson, 1983). Therefore, thematic relations appear to be more rapidly identified for objects that particularly induce action and use experience, namely manipulable objects. This result suggests that the formation of manipulable object concepts may recruit a particular mechanism in which action and use would play a key role. Action experience involvement has been largely described in adult processing of manipulable object concepts (Borghi et al., 2007; Bub, Masson, & Bukach, 2003; Myung et al., 2006; Tucker & Ellis, 2004). The present findings go further by highlighting the role of action in the development of manipulable object concepts as early as age 5.

The opposite pattern was observed concerning basic-level taxonomic relations. They were processed faster for non-manipulable than manipulable objects by both the children and adults. Basic-level taxonomic relations are

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

mainly characterized by perceptual similarity relations. This suggests that the formation of non-manipulable object concepts would particularly rely on visual similarity between objects. This finding is consistent with neuroimaging data that show a specific involvement of the visual cerebral areas when processing non-manipulable object concepts such as animals (Martin, 2007). Moreover, the manipulable/non-manipulable difference was stronger for natural kinds than for artifacts. Basic-level taxonomic processing of natural manipulable objects (i.e., fruit and vegetables, body parts) was particularly slow. It could be that visual similarity relations may be specifically difficult to process when two conditions are combined: a) the perceptual structure of objects is not the most crucial information (manipulable objects) and b) the perceptual structure could not be easily derived from functional information (natural kinds). Concerning artifacts, studies in children (Ahn, 1998; Ahn et al., 2000) and adults (Tyler & Moss, 2001) revealed that artifact functional properties usually determine their superficial features. The strong link between the structure and the function of artifacts may have facilitated the identification of basic-level taxonomic relations between artifacts, either manipulable or non-manipulable. As recently developed by Chaigneau, Barsalou and Sloman (2004), function seems to be a complex relational system that links several types of information such as physical structure and action. Further investigations would be required to specify the functional relational system of different object kinds.

1
2
3
4
5
6
7 We found a distinction in children's processing of manipulable and non-
8
9 manipulable object concepts from age 5. Previous studies in children have already
10
11 shown that perceptual similarity and contextual/functional relations underlie
12
13 conceptual development (Bonthoux & Kalénine, 2007; Borghi & Caramelli, 2003;
14
15 Diesendruck & Bloom, 2003; DiYanni & Kelemen, 2005; Kemler Nelson,
16
17 Frankenfield, Morris, & Blair, 2000; Nelson, 1983; Quinn & Eimas, 2000;
18
19 Sloutsky et al., 2007). The current study further demonstrates that, from age 5,
20
21 perceptual and contextual/functional information is accessible differently for
22
23 manipulable and non-manipulable object concepts. The fact that an object is liable
24
25 to be manipulated may either facilitate (thematic relations) or interfere with
26
27 (basic-level taxonomic relations) conceptual processing. This hypothesis was
28
29 recently tested by Borghi and colleagues (Borghi, Bonfiglioli, Ricciardelli,
30
31 Rubichi, & Nicoletti, In press). They observed that participants were faster to
32
33 categorize manipulable objects than non-manipulable objects when manipulability
34
35 was relevant for the conceptual task ("could objects be picked up and put inside a
36
37 back pack?"). In contrast, object manipulability interfered with conceptual
38
39 processing when it was not relevant for the task ("are objects natural kinds or
40
41 artifacts?"). The type of interaction with objects, namely the possibility to
42
43 manipulate them or not, may be decisive when processing conceptual relations. In
44
45 addition, the influence of the manipulability factor in children's conceptual
46
47 processing suggests that some aspects of their sensorimotor experience may be
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

involved in concept formation. This hypothesis fits into the general framework of embodied views of concepts (e.g., Barsalou, 2008), that has already received important support from studies in adults. A major issue remains how and to what extent concepts are shaped by children's sensorimotor experience with objects.

For Review Only

REFERENCES

- Ahn, W. (1998). Why are different features central for natural kinds and artifacts?: the role of causal status in determining feature centrality. *Cognition*, **69**, 135-178.
- Ahn, W., Gelman, S. A., Amsterlaw, J. A., Hohenstein, J., & Kalish, C. W. (2000). Causal status effect in children's categorization. *Cognition*, **76**, B35-43.
- Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral & Brain Science*, **22**, 577-609.
- Barsalou, L. W. (2008). Grounded Cognition. *Annual Review of Psychology*, **59**, 617-645.
- Bonthoux, F., & Kalénine, S. (2007). Superordinate categorization in preschoolers. *Cognition, Brain & Behavior*, **11**, 713-731.
- Borghi, A. (2004). Object concepts and action: Extracting affordances from objects parts. *Acta Psychologica*, **115**, 69-96.
- Borghi, A., Bonfiglioli, C., Lugli, L., Ricciardelli, P., Rubichi, S., & Nicoletti, R. (2007). Are visual stimuli sufficient to evoke motor information? Studies with hand primes. *Neuroscience Letters*, **411**, 17-21.
- Borghi, A., Bonfiglioli, C., Ricciardelli, P., Rubichi, S., & Nicoletti, R. (In press). Do we access object manipulability while we categorize? Evidence from

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

reaction times studies. In A. C. Schalley & D. Khlentzos (Eds.), *Mental states: Evolution, function, nature* (pp. 153-170).

Amsterdam/Philadelphia: John Benjamins.

Borghi, A., & Caramelli, N. (2003). Situation bounded conceptual organization in children: from action to spatial relations. *Cognitive Development*, **18**, 49-60.

Bub, D. N., Masson, M. E., & Bukach, C. M. (2003). Gesturing and naming: the use of functional knowledge in object identification. *Psychological Science*, **14**, 467-472.

Capitani, E., Laiacona, M., Mahon, B., & Caramazza, A. (2003). What are the facts of category-specific deficits? A critical review of the clinical evidence. *Cognitive Neuropsychology*, **20**, 213-261.

Casler, K., & Kelemen, D. (2007). Reasoning about artifacts at 24 months: the developing teleo-functional stance. *Cognition*, **103**, 120-130.

Chaigneau, S. E., Barsalou, L. W., & Sloman, S. A. (2004). Assessing the causal structure of function. *Journal of Experimental Psychology: General*, **133**, 601-625.

Chao, L. L., & Martin, A. (2000). Representation of manipulable man-made objects in the dorsal stream. *Neuroimage*, **12**, 478-484.

Cree, G. S., & McRae, K. (2003). Analyzing the factors underlying the structure and computation of the meaning of chipmunk, cherry, chisel, cheese, and

1
2
3
4
5
6
7
8
9
10
cello (and many other such concrete nouns). *Journal of Experimental*
Psychology: General, **132**, 163-201.

11
12
13
14
15
Diesendruck, G., & Bloom, P. (2003). How specific is the shape bias? *Child*
Development, **74**, 168-178.

16
17
18
19
20
21
22
Diesendruck, G., Hammer, R., & Catz, O. (2003). Mapping the similarity space of
children and adults' artifact categories. *Cognitive Development*, **18**, 217-
231.

23
24
25
26
27
28
29
Diesendruck, G., Markson, L., & Bloom, P. (2003). Children's reliance on
creator's intent in extending names for artifacts. *Psychological Science*,
14, 164-168.

30
31
32
33
34
35
36
DiYanni, C., & Kelemen, D. (2005). Time to get a new mountain? The role of
function in children's conceptions of natural kinds. *Cognition*, **97**, 327-
335.

37
38
39
40
41
42
43
Filliter, J. H., McMullen, P. A., & Westwood, D. (2005). Manipulability and
living/non-living category effects on object identification. *Brain &*
Cognition, **57**, 61-65.

44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
Gerlach, C., Law, I., & Paulson, O. B. (2002). When action turns into words.
Activation of motor-based knowledge during categorization of
manipulable objects. *Journal of Cognitive Neuroscience*, **14**, 1230-1239.

- 1
2
3
4
5
6
7 Hughes, D., Woodcock, J., & Funnell, E. (2005). Conceptions of objects across
8
9 categories: childhood patterns resemble those of adults. *British Journal of*
10
11 *Psychology*, **96**, 1-19.
- 12
13 Kelemen, D., & DiYanni, C. (2005). Intuitions about origins: purpose and
14
15 intelligent design in children's reasoning about nature. *Journal of*
16
17 *Cognition & Development*, **6**, 3-31.
- 18
19
20 Kellenbach, M. L., Brett, M., & Patterson, K. (2003). Actions speak louder than
21
22 functions: the importance of manipulability and action in tool
23
24 representation. *Journal of Cognitive Neuroscience*, **15**, 30-46.
- 25
26
27 Kemler Nelson, D. G., Chan Egan, L., & Holt, M. B. (2004). When children ask,
28
29 "what is it ?" What do they want to know about artifacts? *Psychological*
30
31 *Science*, **15**, 384-389.
- 32
33
34 Kemler Nelson, D. G., Frankenfield, A., Morris, C., & Blair, E. (2000). Young
35
36 children's use of functional information to categorize artifacts: three
37
38 factors that matter. *Cognition*, **77**, 133-168.
- 39
40
41 Kemler Nelson, D. G., Russell, R., & Jones, K. (2000). Two-year-olds will name
42
43 artifacts by their functions. *Child Development*, **71**, 1271-1288.
- 44
45
46 Mandler, J. M. (2000). Perceptual and conceptual processes in infancy. *Journal of*
47
48 *Cognition & Development*, **1**, 3-36.
- 49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3
4
5
6
7 Marques, J. F. (2006). Specialization and semantic organization: evidence for
8
9 multiple semantics linked to sensory modalities. *Memory & Cognition*, **34**,
10
11 60-67.
12
- 13 Martin, A. (2007). The representation of object concepts in brain. *Annual Review*
14
15 *of Psychology*, **58**, 25-45.
16
- 17 McCaffery, M., & Beebe, A. (1993). *Pain: Clinical Manual For Nursing*
18
19 *Practice*. Baltimore: V.V. Mosby Company.
20
- 21 McRae, K., Cree, G. S., Seidenberg, M. S., & McNorgan, C. (2005). Semantic
22
23 feature production norms for a large set of living and nonliving things.
24
25 *Behavior Research Methods*, **37**, 547-559.
26
27
- 28 Mounoud, P., Duscherer, K., Moy, G., & Perraudin, S. (2007). The influence of
29
30 action perception on object recognition: a developmental study.
31
32 *Developmental Science*, **10**, 836-852.
33
34
- 35 Myung, J.-Y., Blumstein, S. E., & Sedivy, J. C. (2006). Playing on the typewriter,
36
37 typing on the panio: Manipulation knowledge of objects. *Cognition* 1-21.
38
39
- 40 Nelson, K. (1983). The derivation of concepts and categories from event
41
42 representations. In E. K. Scholnick (Ed.), *New trends in conceptual*
43
44 *representation: Challenges to Piaget's theory?* (pp. 129-149). Hillsdale,
45
46 N.J.: Erlbaum.
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3
4
5
6 Pecher, D., Zeelenberg, R., & Barsalou, L. W. (2003). Verifying different-
7
8 modality properties for concepts produces switching costs. *Psychological*
9
10 *Science*, **14**, 119-124.
- 11
12 Pecher, D., Zeelenberg, R., & Barsalou, L. W. (2004). Sensorimotor simulations
13
14 underlie conceptual representations: modality-specific effects of prior
15
16 activation. *Psychonomic Bulletin & Review*, **11**, 164-167.
- 17
18 Quinn, P. C., & Eimas, P. D. (2000). The emergence of category representations
19
20 during infancy: are separate perceptual and conceptual processes required?
21
22 *Journal of Cognition & Development*, **1**, 55-61.
- 23
24
25
26
27 Sloutsky, V. M., Kloos, H., & Fisher, A. V. (2007). When looks are everything:
28
29 appearance similarity versus kind information in early induction.
30
31 *Psychological Science*, **18**, 179-185.
- 32
33
34
35 Sloutsky, V. M., & Spino, M. A. (2004). Naive theory and transfer of learning:
36
37 when less is more and more is less. *Psychonomic Bulletin & Review*, **11**,
38
39 528-535.
- 40
41
42 Stanfield, R. A., & Zwaan, R. A. (2001). The effect of implied orientation derived
43
44 from verbal context on picture recognition. *Psychological Science*, **12**,
45
46 153-156.
- 47
48
49 Truxaw, D., Krasnow, M. M., Woods, C., & German, T. P. (2006). Conditions
50
51 under which function information attenuates name extension via shape.
52
53 *Psychological Science*, **17**, 367-371.
- 54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Tucker, M., & Ellis, R. (2004). Action priming by briefly presented objects. *Acta Psychologica*, **116**, 185-203.

Tyler, L. K., & Moss, H. (2001). Towards a distributed account of conceptual knowledge. *Trends in Cognitive Sciences*, **5**, 244-252.

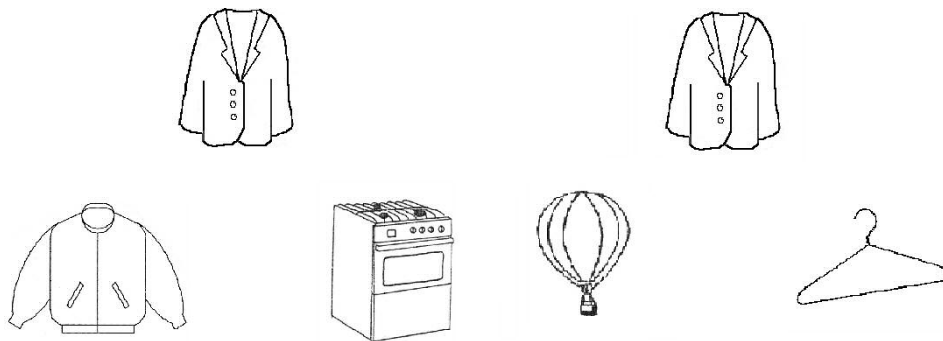
Zwaan, R. A., Stanfield, R. A., & Yaxley, R. H. (2002). Language comprehenders mentally represent the shapes of objects. *Psychological Science*, **13**, 168-171.

FIGURE CAPTIONS

Figure 1: Example of a basic-level taxonomic triad (left) and a thematic triad (right) used for a same target picture; the two central pictures are non-related to the target.

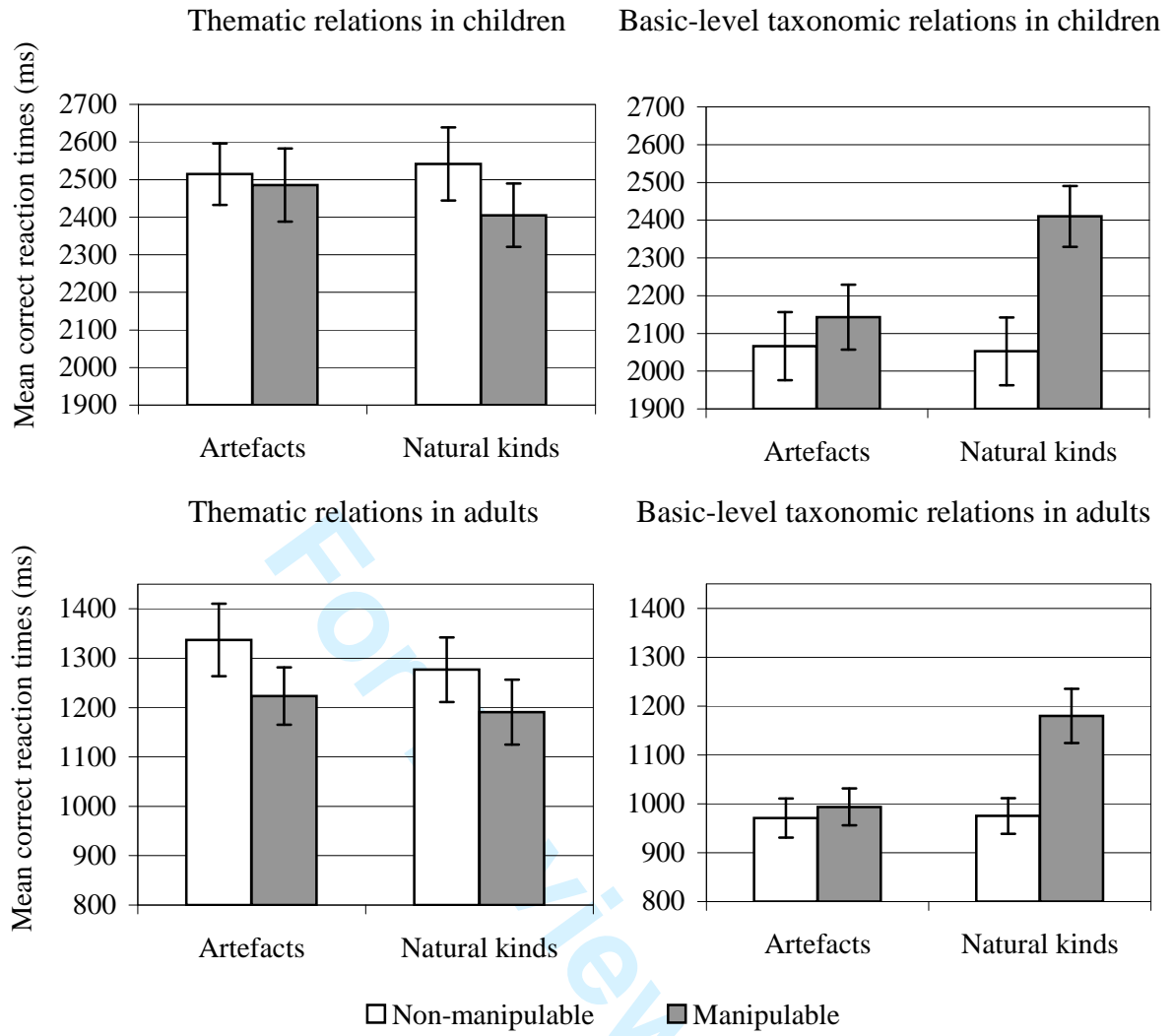
Figure 2: Means and standard errors of correct reaction times for children and adults according to relation type, concept manipulability and domain.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



96x50mm (300 x 300 DPI)

Review Only



1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Complete list of the 40 thematic and basic-level taxonomic triads

	Target	Related picture	Non-related picture
Thematic triads	castle	knight	bulb
	washbasin	soap	princess
	cupboard	pullover	wolf
	armchair	television	hamster
	bus	schoolchild	carafe
	screwdriver	screw	crocodile
	spoon	yoghurt	stairs
	pan	potatoe	glasses
	jacket	hanger	hot-air balloon
	glove	toboggan	swan
	dog	bone	mountain
	squirrel	hazelnuts	clothes peg
	goat	shepherd	helicopter
	mosquito	bite on hand skin	apricot
	baby	feeding bottle	nut
	egg	bird	boat
	orange	bottle of juice	pig
	open hand	pen	ruler
	plant	pot	bat
	tulip	vase	spider
Basic-level taxonomic triads	castle	different castle	dustbin
	washbasin	sink	tamer
	cupboard	chest of drawers	snake
	armchair	sofa	whale
	bus	different bus	phone
	screwdriver	different screwdriver	shark
	spoon	different spoon	barrier
	pan	different pan	match
	jacket	coat	stove
	glove	mitten	octopus
	dog	different dog	cactus
	squirrel	different squirrel	comb
	goat	different goat	crane
	mosquito	fly	com
	baby	different baby	peach
	egg	eggs	church
	orange	different orange	peacock
	open hand	fist	belt
	plant	different plant	crab
	tulip	red poppy	elephant