Alma Mater Studiorum – Università di Bologna

DOTTORATO DI RICERCA IN

Philosophy, Science, Cognition, and Semiotics (PSCS)

Ciclo XXXIII

Settore Concorsuale: 11/E1

Settore Scientifico Disciplinare: M-PSI/01

AFFORDANCES AND LANGUAGE: HOW THE LEVEL OF OBJECT FAMILIARITY MODULATES THE MANIPULATION AND CATEGORIZATION OF OBJECTS ACROSS DEVELOPMENT

Presentata da: Laura Rio

Coordinatore Dottorato

Prof. Claudio Paolucci

Supervisore

Prof. Roberto Nicoletti

Esame finale anno 2021

ABSTRACT

According to much evidence, observing objects activates two types of information: structural properties, i.e., the visual information about the structural features of objects, and function knowledge, i.e., the conceptual information about their skilful use. Many studies so far have focused on the role played by these two kinds of information during object recognition and on their neural underpinnings. However, to the best of our knowledge no study so far has focused on the different activation of this information (structural vs. function) during object manipulation and conceptualization, depending on the age of participants and on the level of object familiarity (familiar vs. non-familiar). Therefore, the main aim of this dissertation was to investigate how actions and concepts related to familiar and non-familiar objects may vary across development. To pursue this aim, four studies were carried out. A first study led to the creation of the Familiar and Non-Familiar Stimuli Database, a set of everyday objects classified by Italian pre-schoolers, schoolers, and adults, useful to verify how object knowledge is modulated by age and frequency of use. A parallel study demonstrated that factors such as sociocultural dynamics may affect the perception of objects. Specifically, data for familiarity, naming, function, using and frequency of use of the objects used to create the Familiar And Non-Familiar Stimuli Database were collected with Dutch and Croatian children and adults. The last two studies on object interaction and language provide further evidence in support of the literature on affordances and on the link between affordances and the cognitive process of language from a developmental point of view, supporting the perspective of a situated cognition and emphasizing the crucial role of human experience.

Table of contents

ABSTRACT 3
INTRODUCTION 9
PART I 13
THEORETICAL PANORAMA 13
CHAPTER 1 15
AFFORDANCES AROUND US 15
1.1. Affordance. The origin of the concept 15
1.2. Affordances are grounded in perception and action. The Embodied and Grounded Cognition Theories 17
1.3. Different types of affordances 19
1.3.1. Specific components of grasping. Microaffordances 20
1.3.2. Structural and functional properties of objects. Manipulative and function affordances 21
1.3.3. The stability and variability of the world. Stable, canonical and variable affordances 22
1.3.4. Invitations from one or more objects. Multiple affordances 24
1.3.5. All or nothing. Broken affordances 25
1.3.6. Stay away from it! Dangerous affordances 26
1.3.7. The social side of affordances 29
1.4. Where affordances fire. Neural localization 31
1.4.1. The dorsal and ventral streams 31
1.4.2. The dorso dorsal and ventro dorsal pathways 34
1.4.3. The Two Action Systems and the Two Action Systems Plus models 35
1.4.4. The Three Action Systems model 38
1.5. Actions related to objects. Theoretical Summary 41
CHAPTER 2 43
AFFORDANCES AND LANGUAGE 43
2.1. What are concepts? Theories and beliefs 43
2.1.1. From the Classical Theory, across the Prototype and Exemplar accounts, to the Frames model 44
2.2. How object categorization is organized. The hierarchical model 48

2.2.1. Basic, subordinate, and superordinate concepts. Evidence from infancy and adulthood 50

2.3. Concept combination in children and adults. Thematic, partonomic and taxonomic relationships 53

2.3.1. Correlations between properties and roles. Evidence from children 55

2.4. The importance of structural and functional information in object concept categorization 58

2.5. Where object concepts are rooted. The brain localization 59

2.6. Concepts related to objects. Theoretical Conclusions 61

PART II 63

EXPERIMENTAL EVIDENCE 63

CHAPTER 3 65

STUDY 1: THE FAMILIAR AND NON-FAMILIAR STIMULI (FANS) DATABASE. A COLLECTION OF EVERYDAY OBJECTS CLASSIFIED BY CHILDREN AND ADULTS 65

Introduction 65

Method 74

Analysis 79

Results 86

General discussion 108

CHAPTER 4 113

STUDY 2: CROSS CULTURAL CORRELATION AMONG ITALIAN, DUTCH AND CROATIAN POPULATIONS ON THE FANS DATABASE 113

Introduction 113

Method 115

Analysis 118

Results 119

General discussion 127

CHAPTER 5 131

STUDY 3: CHILDREN ARE MORE RESPONSIVE TO FUNCTION KNOWLEDGE THAN ADULTS IN INTERACTING WITH FAMILIAR AND NON-FAMILIAR OBJECTS. 131

Introduction 131

Method 136

Analysis 138
Results 138
General discussion 143
CHAPTER 6 147
STUDY 4: TOYS ARE MORE FAMILIAR THAN DOLLS. OBJECT FAMILIARITY AND HIERARCHICAL LEVEL OF CATEGORIZATION 147
Introduction 147
Method 154
Analysis 156
Results 158
General discussion 170
CONCLUSIONS AND FUTURE PERSPECTIVES 175
BIBLIOGRAPHY 183
SITOGRAPHY 215
APPENDIX A 217
APPENDIX B 253
APPENDIX C 261
APPENDIX D 265

INTRODUCTION

Our life is a constant interaction with objects: when we eat, for example using forks, spoons, glasses; when we study, for example reading books or manipulating pencils; when we do sport, for example jumping a rope, and so on. A couple of decades ago, Norman (1997) stated that there were about twenty thousand objects around us. Nowadays, the weight of artificial artifacts has even exceeded that of living beings (Elhacham et al., 2020). Hence, it is hard to imagine a day in which we do not use objects to achieve goals.

Each object has its specific function and its way of use. An intriguing question is: What allows us to understand how to use an object? The answer comes from the relationship between the physical properties of an object and the environment. In particular, from the invitations and constraints of action, namely from the *affordances* (Gibson, 1977; 1979). Indeed, according to Gibson's ecological perspective, we do not perceive the individual physical features of objects. Rather, we perceive the possibilities for action they suggest.

Over the last twenty years, several studies have focused on the Embodied Cognition theories, the views according to which cognitive processes are grounded in perception and action through a body that interacts with the environment (Barsalou, 1999; 2008). Within this framework, the role that familiar object affordances play during processes such as action planning and concept categorization has been widely investigated. To the best of our knowledge, very few studies have aimed at investigating how this information may be differently activated depending on the age of an individual and on the level of object familiarity. In light of this, this dissertation focuses on actions and concepts related to familiar and non-familiar objects and examines how these may vary across development. It is divided into two parts: a theoretical part, covered by Chapter 1 and Chapter 2, and an experimental one, from Chapter 3 to Chapter 6.

The main question of Chapter 1 is “What is an affordance?”. Firstly, it is reported and discussed the definition proposed by Gibson, the first to coin the term, according to which affordances are the intrinsic and perceived properties of material things offered by the environment. Second, it is examined how the concept of affordance has been widely contemplated within the embodied perspective of cognition. After that, the different types of affordances that may be perceived depending on the physical properties of objects, on the condition of our body, and on the current situation are presented. In particular, the attention is focused on the distinction of affordances based on the structural properties, such as the shape, the size, the orientation, and on the functional information of objects, namely on their use. Moreover, it is emphasized the fact that evidence on these aspects comes exclusively from adult interaction with familiar objects, and that the performances of children and preadolescents would be interesting to investigate.

The second theoretical chapter deals with the link between affordances and the cognitive process of language. Firstly, the definition of the term *concept* is elucidated by reviewing some of the influential theories of conceptual knowledge (Borghi 1997; Smith & Colunga, 2012 for reviews). The Classical approach (Smith & Medin, 1981), and the Prototype and Exemplar theories (Medin and Schaffer, 1978; Brooks, 1987) are then expounded. Finally, it is described the model of frames (Barsalou, 1992; 1993) that organize the information in a hierarchical way, giving rise to taxonomic levels of categorization. In this regard, the description of the three levels of categorization, the superordinate, the basic, and the subordinate one is reported, and the most dominant evidence in developmental literature is examined. In addition, it is explained the way concepts, being hierarchically organized, and so operating in an inclusive manner, combine one another generating different types of relationships. Furthermore, the most investigated relationships, i.e., those thematic, partonomic and taxonomic are described. Also in this case it is reported the dominant evidence in developmental research.

By reviewing the literature reported in Chapter 1 and Chapter 2, it was noticed the lack of data from children and preadolescents on the activation of structural and functional affordances during object manipulation and linguistic process. Thus, it was found interesting exploring how the variable of object familiarity may affect these processes, across development. Therefore, the main aim of this thesis was to investigate whether the different degrees of object familiarity and the age of an individual can affect: a) the interaction with objects, in terms of motor activation of structural and function affordances; b) the conceptual level at which objects are categorized (subordinate, basic, superordinate), the conceptual relationships elicited by objects (thematic, taxonomic, partonomic), and the role of structural and function information in object concept categorization.

In planning the experimental designs of the studies described in the second part of this dissertation and, specifically, in choosing the stimuli, it was realized that a collection of both familiar and non-familiar everyday objects, classified by individuals of different ages, is missing in literature. In this regard, in Chapter 3 it is described the first study aimed at creating the Familiar and Non-familiar Stimuli (FANS) Database, namely a set of everyday objects classified by Italian pre-schoolers, schoolers, and adults, useful to verify how object knowledge is modulated by age and frequency of object use. In Chapter 4 it is detailed the parallel study conducted by involving Dutch and Croatian populations. Specifically, the study aimed at operating a cross cultural analysis between Italian and other populations, and permitting researchers from different countries to use this instrument.

The findings obtained in Chapter 3 were crucial to design the studies in Chapter 5 and Chapter 6, aimed at addressing the main questions of this dissertation. In Particular, Chapter 5 describes the study performed to verify whether children, preadolescents and adults would be affected by the different degrees of object familiarity in choosing structural, functional and alternative grasp responses when interacting with objects. Interestingly, the phenomenon of functional fixedness is discussed. While Chapter 6 reports the study aimed at investigating how children (two groups, from 3 to 5, and from 6 to 9 years old), preadolescents, and adults categorize more familiar and less familiar object concepts, in terms of object concept categorization level, i.e., basic vs. subordinate vs. superordinate, conceptual relationships, i.e., thematic vs. partonomic vs. taxonomic, and object information types, i.e., structural vs. function knowledge.

PART I

THEORETICAL PANORAMA

CHAPTER 1

AFFORDANCES AROUND US

1.1. Affordance. The origin of the concept

The first one to coin the term “affordance” was James J. Gibson in 1977. In devising it he referred to what the Gestalt psychologists called *Aufforderungscharakter* (Lewin et al., 1926), invitation-character (Brown, 1929), or valence (Adams, 1931), i.e., vectors that invite or reject someone toward or away from an object (Lewin, 1938). In line with Gestalt theorists, these vectors are mainly dependent on the intentions of the viewer. For instance, as reported by Koffka (1935), someone is attracted by a post box only because he needs to send a letter, not for other reasons. In this way, if the intention of the viewer changes, vectors also change. Gibson’s perspective accepted the idea of vectors, but disapproved the assumption that affordances change as the intensions of the viewer change.

Gibson called affordances the physical properties that the environment offers animals and people, such as the ground, the water, the air, materials, etc. Each of these physical properties has a surface and a substance. Depending on the characteristics of the surface and the substance, its affordances acquire different meanings. For instance, if a tree has a rigid trunk and stable branches, then it will be suitable to support animals; the liquid substance of water, instead, is not appropriate as a support but rather as a fluid to drink or useful for a bath. Importantly, the author stressed the fact that the physical properties of the environment must not be understood in their objective meaning, i.e., as mere physical qualities of the surrounding space. Rather, they must be interpreted from an ecological perspective, i.e., they must be linked to the behaviour of the perceiver as a sort of mutual interaction between the agent and the world, between the characteristics of people and animals and conditions of the environment, between proprioception and exteroception.

In defining affordances, Gibson also referred to the concept of niche employed by ecologists to indicate the way in which animals live. According to this concept, an interdependent relationship between animals and their niche exists: animals belong to a specific niche, and a niche includes specific animals. In this interdependence the environment offers all the conditions necessary to make possible the coexistence of the niche and the animals. It namely provides ground on which to move, water in which to swim, caves to hide in and shelter from the cold, food to eat, and all kinds of materials that can be manipulated to make tools and objects.

Besides being supplied by surfaces and substances of the terrestrial environment, affordances are also offered by objects, other animals, and other people. Regarding objects, Gibson distinguished attached objects from detached ones. The first are immovable objects that can be grabbed but not removed from their location (e.g., a tree or a mountain). The latter are, instead, objects that may be grasped, lifted, and moved from one place to another (e.g., a stone). Importantly, to be graspable, an object must have specific features which are compatible with the characteristics of the agent, such as size, shape, weight, width, and so on. For instance, a monkey will be able to grab and carry a banana, but it will not be able to move a large stone, especially if it is not round in shape (so as to facilitate rolling). Among detached objects, Gibson also included other animals and other persons, since they move, walk, jump, fly, swim. Obviously, they differ from the aforementioned objects, since they are living, dynamic and not inanimate entities. As the author emphasized, they represent more complex offerings than non-living objects since these are originated from sensible surfaces such as the skin, and from particular stimuli such as their smell, voice, cry, contact. Moreover, these animate objects generate social behaviours, while inanimate objects do not. With social behaviours Gibson intended caring, supporting, cooperating, but also rejecting and hitting. Notably, the positivity or negativity of the behaviour depends on the perception or misperception of the viewer.

In sum, according to Gibson, affordances are visual properties that the environment endows animals and people. These must not be understood in their physical meaning, but must be described in an ecological perspective. They namely must be linked to the behaviour of the perceiver. Finally, these are directly perceivable.

1.2. Affordances are grounded in perception and action. The Embodied and Grounded Cognition Theories

The last twenty years have seen the spread of an embodied and grounded cognition view, namely, the theoretical approach according to which cognition is grounded in perception and action, through a body interacting with its environment (Barsalou, 1999; 2008). In this framework, the notion of affordance has been considered extensively since, as seen in the previous section, it implies both perceptual and motor systems.

Before delving into how affordances have been employed in the embodied and grounded cognition perspectives, discussing the principles underlying these approaches is necessary.

The traditional view on mind considered the body not to be relevant to understand human cognition. According to the exponents of embodied cognition theory, it is exactly the opposite, namely, cognitive processes are highly dependent on the human body and precisely on the sensorimotor system (Wilson, 2002; Foglia and Wilson, 2013; Wilson and Foglia, 2017). Over the years the embodied cognition perspective caught the interest of authors of different disciplines, from neuroscience to psychology, from philosophy to linguistics. Depending on which embodied perspective was accepted, the perspective tended to be more or less radical. The basic idea was to emphasize the assumption that our mental processes are bound not only to the brain but also and especially to the body and the environment. In this regard, some authors have proposed conceptual clarifications, e.g., Fischer (2012), Pezzulo et al. (2011), Goldman and De Vignemont (2009) and thus four other different labels for cognition, besides that of embodied, have been identified, namely grounded, situated, enacted, extended.

Grounded cognition is fundamentally based on the idea that cognitive processes are affected by constraints which are typical of the physical world (note the explicit reference to the word ground in the term) and which also include restrictions of our sensorimotor system. Indeed, according to Barsalou et al. (2008) cognition is not necessarily grounded in bodily states, but also in simulations of non-present situations and more generally in situated experiences. Detachment from the body suggests that cognition may also operate separately from the physical body that coded the sensorimotor experience.

The term situated is related to the characteristics of the environment and the context, including social and cultural aspects. Thus, cognitive processes are defined as "situated" when they depend mostly on contextual factors.

The concept of enaction was introduced by Varela et al. in 1991 to stress the idea that a perceptual system is the result of the interaction between the sensorimotor system and the environment. In other words, enactivism focuses its attention on sensory experience during exploration, thus assigning to the motor system a crucial role in cognitive abilities (O'Regan and Noë, 2001; Ward and Stapleton, 2012).

The idea of extended cognition comes from the Extended Mind Thesis (EMT) developed by Clark and Chalmers (1998), according to which cognitive states are extended beyond our brain and skin into the physical world. In addition, in their proposal, the authors considered the objects within the environment (e.g., diary, notebook) as helpers of our cognitive functions.

1.3. Different types of affordances

As seen in the first section, depending on the physical properties of objects, on the condition of our body, and on the current situation, different types of affordances may be perceived. Gibson (1977; 1979) assumed that these characteristics are recorded directly by our perception with no need of prior knowledge about the nature of the object. Thus, it is not necessary to know that an apple is an apple: our hands adapt their shape to grasp it independently of our previous experiences. Over the years, much research demonstrated that several authors, while referring to Gibson's perspective, disagreed with it.

1.3.1. Specific components of grasping. Microaffordances

Ellis and Tucker (1998; 2000; 2001) agreed that affordances are activated automatically, but they found that it is also necessary to activate knowledge related to the object to guide actions. They then ascribed crucial relevance to the brain, namely to our neural representation of the object. In particular, they proposed the term microaffordances to indicate “specific components of grasping” (Ellis and Tucker, 2000; p. 467) that involve congruent configuration of the hand and fingers, and specific orientation of the wrist to grasp the object appropriately. For instance, small or thin objects, such us a pencil or the petiole of a leaf, need a precise grip (i.e., a pinch with the thumb and the index finger); instead, bigger objects (graspable with a hand), such as an apple or a bottle, need a powerful grip (i.e., a clench with the palm and fingers). To test this congruence, Tucker and Ellis (1998) adopted the Stimulus-Response Compatibility (SRC) paradigm. They presented graspable objects with the handle oriented to the right or to the left. Participants were asked to respond as fast as possible to indicate whether the objects were upright or inverted by pushing a right or left button with their corresponding fingers. Results showed that participants were quicker when the response spatially corresponded to the orientation of the handle of object than when the orientation of the handle and the response were opposite. For example, they were quicker when they had to respond with the right button if the handle of the object was right-oriented.

1.3.2. Structural and functional properties of objects. Manipulative and function affordances

Similarly to Tucker and Ellis, Bub et al. (2008) considered that affordances are automatically evoked by objects, but through memory representations and the intentions to act on or with them. They differentiated grasping gestures associated with the function of the object from those adopted to grip the object based on its structural characteristics such as shape. With regards to structural properties, the authors used the term volumetric. Interestingly, for some objects the two kinds of grasping gestures correspond. For instance, a smartphone is associated with two different gestures, i.e., a clench to grasp and a poke to use it; while a glass is associated with the same gesture both to grasp and to use it, i.e., a clench.

The differentiation made by Bub and colleagues is comparable to that employed by Johnson and Grafton (2003) since they distinguished the "actions on" from the "actions with" an object. The distinction is also analogous to that proposed by Jax and Buxbaum (2010). Specifically, when classifying affordances based on the structural properties (e.g., shape, size, orientation) and on the functional information (i.e., on the use) of an object, they associated objects with two action classes: grasping in accordance with their structure and grasping consistent with their function. Since these two action classes may or may not be applicable for the same object, the authors conceptualized objects as conflict and non-conflict. The first are objects with competing structure and function responses, e.g., a blender is associated with different actions for structural and functional responses (i.e., clench to grasp, poke to use); while the second are objects associated with the same grasp action response, e.g., a screwdriver (clench to grasp and use). Interestingly, Jax and Buxbaum conducted an analysis on initiating actions by comparing common conflict and non-conflict objects. They asked participants to perform two tasks: a grasp task where they had to place the hand on the objects as they would to pass them to someone, and a use task where they had to place the hand as they would to use them. In particular, half of the participants was asked to perform first the use and then the grasp task; the residual participants were asked to perform the tasks in the opposite order. Analysing the initiation times, the authors found that, in general, grasp responses were faster than those related to the use; they then noted that grasp actions toward the conflict objects were longer when the grasp task was presented after the use task; finally, they observed slower reaction times during the use responses toward conflict objects independently of the task order. The general interpretation was that functional responses involve the activation of long-term conceptual representations, while grasp responses do not. These results confirmed that the activation of affordances is automatic, but also emphasized the necessity to activate our object representations to guide the actions.

1.3.3. The stability and variability of the world. Stable, canonical and variable affordances

In trying to understand the mechanisms underlying the activation of affordances, Borghi and Riggio (2009; 2015) considered objects' relevant features, the motor responses they evoked and the contextual variables, and proposed new different types of affordances, i.e., stable, canonical and variable ones. Overall, the authors started from the assumption that affordances are not mere properties of objects. Rather, affordances refer to the brain representations of the interaction between an agent who acts with objects within the environment.

Stable affordances are defined as the association between all those invariable characteristics of objects (e.g., size, shape) and the actions the agent performs with them. For example, if we consider a pencil and a book, we know that picking up a pencil requires a precision grip, while grasping a book takes a power grip. This is because we know that these objects typically have that size and that shape, i.e., their stable features, and that interacting with them requires those actions. This knowledge is due to the fact that stable affordances are stored in memory as object representations.

Canonical affordances are identified as a subcategory of stable affordances since they derive from features that may change during our interaction with the object, e.g., the orientation. For example, a pencil may change orientation depending on the context (e.g., it may be lying on the table or upright in a pencil holder with the tip pointing upwards), but its canonical affordance is the typical orientation it manifests when we interact with it, i.e., upright with the tip toward a piece of paper. Overall, canonical affordances can be associated with the most typical context in which an object may be found (e.g., in a pencil case), the actions we usually perform with it (e.g., handle it) and the common goals we achieve with it (e.g., draw).

Variable affordances, unlike stable ones, derive from flexible object information and mostly depend on the context and the actions we want to perform. They are characteristics that need continuous updates, namely they need to be repeatedly reprocessed every time the context and the intensions of the agent change. For example, an object may be lying on a table, inclined in a bag, or in other position; based on this variability, we have to adapt our motor responses to the location and orientation of the object, in order to grasp it in the right way and according to our goals. In view of this variability, in contrast with stable affordances, this kind of information is not stored in memory.

1.3.4. Invitations from one or more objects. Multiple affordances

As we have seen, affordances may be offered by the same object which evokes various motor responses (Jax & Buxbaum, 2010), but they may also be elicited from different objects. In both cases, we can talk about multiple affordances. For example, Pezzulo and colleagues (2010), explored how climbers of different levels of expertise memorized affordances offered by sequences of holds arranged in three routes (they never climbed) of three different difficulty levels. The results showed that seeing the climbing wall activated a motor simulation that mostly depended on the climber's motor competence. According to the authors, the activation of this simulation facilitated the climber's recall.

Other examples of studies on multiple affordances comes from Yoon and colleagues (2010) and Borghi and collaborators (2012). In both studies, participants were presented with pairs of objects, such as a knife and butter, the affordances of which could be merged to achieve goals. Specifically, in the first study right-handed participants had to decide whether two objects were usually used together or whether they commonly appeared within a given context. The objects were presented in standard and opposite orientation for right-handed grasp. The results demonstrated that participants were quicker at deciding whether two objects were commonly used together when the objects were presented in standard orientation. In the second study, participants were presented with images of pairs of objects combined according to a functional (scissors and papers), spatial (fork and spoon) or no relation (bottle and brush) construct. The images also showed a hand in one of four conditions, i.e., near the objects, grasping an object to pick up it, grasping an object to use it, no hand was shown. Participants had to establish whether objects were linked or not by pressing a button. Reaction times were: a) faster when objects were functionally linked, b) slower when a manipulative grasp was displayed in a functional relation and c) slower when a functional grasp occurred in a spatial relation.

Overall, the idea is that multiple affordances are automatically activated and that some of these are not selected since they are not considered relevant to the current situation and/or to the goals of the agent.

1.3.5. All or nothing. Broken affordances

There are situations in which, instead of reacting to affordances, we need to avoid reacting to the information they offer. This is the case of broken affordances, i.e., “invitations” that cannot be utilized because, for example, they are broken. An example comes from a TMS study by Buccino et al. (2009). They presented common objects with a broken or whole handle, placed to the right or to the left of the objects. Participants were asked to observe stimuli attentively. The left hemisphere hand motor area was magnetically stimulated. The data showed that the Motor Evoked Potential area was bigger when the handle of the objects was whole and presented to the right of the object. Instead, when the handle was broken, regardless of the position, either the activation in the cortical area was absent or there was a suppression (inhibition) of the affordances after their activation.

With regards to the inhibition of affordances, Riggio et al. (2006) studied this reaction adopting the Inhibition of Return (IOR), a paradigm according to which a delay occurs in answering a target when it is preceded by an irrelevant stimulus at the same location. Specifically, while participants fixated a point in the centre of the screen, two stimuli, i.e., a whole object with clearly distinct graspable and ungraspable parts and the individual parts were displayed. The whole object represented the cue, while the graspable and ungraspable object parts represented the targets. The stimuli were displayed either in a peripheral location or in symmetrical location to the right or the left of the visual field. Participants were asked to ignore the cue and react to the target, i.e., to the parts of objects. The results revealed that responses were slower when the graspable part was displayed in the peripheral location than when the ungraspable part was shown in the same location. The authors justified the effect as associated with the kind of action relevant to grasp a specific object.

Overall, although more studies are needed to better comprehend the process underlying the activation of broken affordances, the shared idea so far is that their activation may be completely absent or be present but then suppressed.

1.3.6. Stay away from it! Dangerous affordances

Dangerous objects present a similar case to broken affordances. With dangerous objects, we avoid activating affordances or we activate them but then inhibit them. Anelli et al. (2012; 2013a; 2013b) performed different studies with participants of different ages to explore this phenomenon.

In an early study (2012), the authors investigated whether children were receptive to the difference between dangerous and neutral objects. In addition, they probed whether children were affected by an agent who interacted with the two categories of objects. Specifically, they contrasted human and robotic hands, and hands of different genders (male and female). To address these aims, the authors used a priming task asking children and adults to categorize the objects into neutral or dangerous by pressing two different buttons on a keyboard. The results of this study revealed that children were able to discern between the two categories of objects, but manifested slower reaction times in the distinction of dangerous objects. Moreover, quicker responses were found when the grasping hand was that of a human than that of a robot in reacting to dangerous objects, suggesting that the inhibition is higher when the hand is similar to one's own hand. As to the difference between the male and female hands, greater vulnerability was detected with a female hand.

In a later study (2013a) Anelli et al. included three experiments with the aim to verify whether the observation of dangerous and neutral objects affected motor responses and the response time in reacting to dangerous objects. The objects belonged to artifact and natural objects, of different sizes (small, normal, and big), and were presented in one of two different conditions, i.e., in a static (close or distant from the participant) or a dynamic way (in movement toward or away from the participant). The images of the objects were displayed with different timing in the second and third experiments: in the second experiment, 1s passed between the presentation of the first and the subsequent image; in the third experiment, no time passed between one image and another. The authors asked children and adults to detect the object category, by pushing or releasing a button on the keyboard. The findings showed faster responses when objects were dangerous, and they moved away from participants; and when objects were neutral, and they moved toward participants. Concerning the dynamic or static condition, the authors found quicker responses for neutral than for dangerous objects in the non-dynamic situation. As for the objects' size, an effect associated with the different time in presenting objects was found. Specifically, when participants had more time to formulate their response, they were faster with big (hence nearer to participant) and dangerous objects; instead, when they had less time, they were slower with big objects. The authors suggested that these findings may show that when there is no time for action preparation, and dangerous objects are approaching us, a sort of blocking effect occurs.

Finally, in a more recent study (2013b), Anelli et al. investigated sensitivity to dangerousness by presenting adults and teenagers with neutral and dangerous objects laid out on a line. Participants were required to indicate the midpoint of the line. Results revealed that both teenagers and adults analytically divided the line toward the neutral object, demonstrating that participants were attentive to dangerous objects and that this attention is preserved across the development.

In sum, these three studies provide interesting insights on dangerous affordances, suggesting that when we are faced with dangerous objects, instead of activating their affordances and then inhibiting them, as in case of broken affordances, we directly block them with an aversive behaviour.

1.3.7. The social side of affordances

Studies on affordances have focused not only on the motor actions elicited by objects within a physical environment, but also on the social aspects involved in their recognition.

An interesting effect derives from the social convention in a given culture. For example, we use the fork in a specific way, because that is the way we were taught to do it. In other cultures, instead, the fork is used in a different way from ours, in others it is not used at all. Our culture "compels" us to behave in a certain way. As stressed by Borghi et al. (2011), the use of an object in a way which is not conventionally accepted by one's own culture (e.g., not using the fork to bring food to the mouth) might cause social failures, such as receiving unpleasant comments from others.

The detection of affordances may also be affected by the presence of other people. Gianelli et al. (2011) used a joint paradigm to address this aspect. They asked participants to perform a task in which they had to hold a mouse and move it away from or towards the body based on object-related sentences they read on the screen while another person is sitting in front of them or interacting with them. Overall, the results showed that the presence of the other person affected motor performance particularly when the other was interacting with the participant. Interestingly, they found that the presence of an observer or someone who interacts with participants led them to pay more attention to aspects related to object grasping.

In a subsequent study (Gianelli et al., 2013), the authors explored how reaching and grasping objects are influenced by the presence of a known or unknown person. The most interesting findings revealed quicker reaction times when participants were in the presence of known persons and in locations permitting them to easily reach for the object. According to the authors, this was justified by the fact that people are more inclined to share their space and things with known people than with unknown ones.

Other interesting studies have been conducted by Ferri et al. (2010; 2011). In the first study (2010), they started with the assumption that facial expressions influence motor behaviour by transmitting emotional states. Specifically, the authors adopted a kinematic approach to investigate whether the execution of an action directing another person is modulated by the emotions (happiness, disgust, anger, or neutral) manifested by that same person. Moreover, they explorered whether the action performance may vary based on participants' empathy. What the authors found was that the emotion of disgust caused faster reactions, while the anger expression, although it was a negative emotion like disgust, did not. Interestingly, when the person manifested positive emotions (happiness), both an early acceleration and a slower end-part action execution occurred, thus manifesting a greater attention to accuracy in the execution of the movement.

The second study (Ferri et al., 2011) included a series of experiments in which authors aimed at detecting which aspects influence the interaction between humans and non-humans. Specifically, participants, acting as givers, were asked to approach human and non-human actors (receivers), in a feeding, touching, and placing task. Overall, the results demonstrated that a social affordance effect was triggered more when approaching humans than non-humans and feeding them. This was because the opening of the mouth, in addition to the gaze of the human, represented a clear request for social behaviours.

To summarise, the reported studies are definitely useful for affirming the importance of the social aspects in affordance detection and motor planning. However, further studies are needed to better understand the relationship among them.

1.4. Where affordances fire. Neural localization

The emergence of the embodied cognition approach that, as seen in the second section, considers cognition to be the result of simulations of our previous sensory and motor experiences, has increased scientific interest about the cortical networks involved in visual processing. Originally, two visual processing circuits were considered to be involved in human's perception of visual information: the dorsal and the ventral streams. Additional anatomical and neuropsychological investigations indicated the presence of two further routes within the dorsal system, i.e., the dorso-dorsal and ventro-dorsal pathways.

1.4.1. The dorsal and ventral streams

The most dominant view claims that there are two different visual processing routes in the human brain that play distinct but complementary roles in the perception of visual information. They are the dorsal and the ventral streams, and they are located in the inferior temporal and posterior parietal cortex (Ungerlieder and Mishkin, 1982; Milner and Goodale, 1991; 1995).

Originally, in the early 1980s, the dorsal stream (occipito-parietal pathway, stretching from the primary visual cortex V1 in the occipital lobe to the parietal lobe, including the V5 area) was thought to be devoted to spatial perception, namely to where an object is located. Conversely, the ventral (occipito-temporal pathway, moving from the primary visual cortex V1 to the inferotemporal cortex IT, involving the V4 area) was specialized for object perception (shape, colour), namely, to identify what an object is (Ungerlieder and Mishkin, 1982).

Later, a revised version of the two-visual systems model was proposed by Milner and Goodale (1995; 2008). They contradicted Ungerlieder and Mishkin's view by giving a functional role to the dorsal stream. Specifically, according to the authors, the occipito-parietal pathway receives sensory information and computes it into information for action, thus becoming a system specialized in how to organize actions. Hence, the ventral stream is fundamental for perception, while the dorsal stream is important for processing visual stimuli and providing high order visual information for the organization of actions. Importantly, it is not related to perception.

An analogous perspective was offered by Jeannerod (1994, 1997). The author distinguished between a semantic and pragmatic system. The first is associated with the ventral stream and refer to the semantic recognition of objects, while the second refer to the stimuli processing necessary to perform an action and is associated with the dorsal stream.

As emphasized by Gallese (2007), although the distinction proposed by Jeannerod seemed to be less strict than that of Milner and Goodale, the basic assumption of the two views is remarkably similar.

The dorsal stream has aroused particular interest among researchers. For example, Sakata et al. (1995) studied the activity of the neurons located in the posterior bank of the intraparietal sulcus (IPS) involved during hand manipulation. Their analysis led to the classification of neurons into three main groups: motor-dominant, visual-dominant, and visual and motor neurons. The first group is activated when a movement is executed both with and without visual control; the second group exclusively when the grasping is executed with visual control; the third group is mostly activated when the movements are under visual control. The last two groups are then divided into other two classes, i.e., object type and non-object type neurons. Interestingly, the first class are activated also by the visual presentation of 3D objects without any kind of related movement, suggesting that even the dorsal system is able to detect objects' features such as shape, not only the ventral one. According to Gallese et al. (1999), these results were crucial for neuropsychological research because for the first time the sharp distinction between ventral and dorsal routes was blunted.

Subsequent experiments on monkeys confirmed that a great number of neurons in the dorsal circuit is implicated in the coding of hand grasping movements. For example, Rizzolatti et al. (1996) noted that in area F5 of the monkey premotor cortex, neurons, the canonical ones, activated both when the monkey performed an action, and when he observed another monkey or a human performing an action such as grasping, holding, or manipulating objects. In particular, it was found that neurons were more sensitive to specific kinds of grasp, i.e., to those with the whole hand, with only fingers, and precision ones (Rizzolatti and Luppino, 2001).

As seen in the section concerning the different types of affordances, visual features of objects have to be integrated with conceptual information, in order to allow us to interact appropriately with them. Hence, a combination between dorsal and ventral neural functions is necessary. Indeed, further anatomical and neuropsychological studies suggested the presence of two additional routes within the dorsal system (Tanne-Gariepy et al., 2002), especially devoted to reaching and grasping actions (Galletti et al., 2004), even in patients with motor (grasping) impairments due to lesions of the anterior intraparietal sulcus (Binkofski et al., 1998), i.e., the dorso-dorsal and the ventro-dorsal circuits (Rizzolatti and Matelli, 2003). This discovery confirmed the assumption raised by Gallese et al. (1999) that the ventral and dorsal pathways cannot be considered separately. Below is a description of the two additional circuits.

1.4.2. The dorso dorsal and ventro dorsal pathways

Rizzolatti and Matelli (2003), when further analysing the anatomy of the brain, discovered that the dorsal pathway is formed by two others anatomical and functional systems: the dorso-dorsal and the ventro-dorsal stream. The dorso-dorsal stream involves the V6 area, and the V6A and MIP areas of the superior parietal lobule (SPL) and reaches the dorsal pre-motor areas. The ventro-dorsal stream, instead, includes the medial superior temporal (MTS) area, the inferior parietal lobule (IPL) and the ventral premotor cortex. According to the authors, the two streams have distinct roles: the dorso-dorsal circuit control the online process during the execution of an action; whereas the ventro-dorsal circuit recognizes the actions performed by other people and the location where they are performed.

As explained in previous sections, prehensile actions can be differentiated in grasp-to-move and grasp-to-use actions. In accordance with this distinction and the two additional pathways described above, two other specific routes have been proposed by several authors (Buxbaum, 2001; Johnson-Frey, 2004; Pisella et al., 2006). The first is dedicated to the grasp-to-move actions; it is a bilateral system, and it is placed between the intraparietal sulci and the superior parietal lobules. Its role is to compute action information from the characteristics of the agent and the environment, and to maintain it for short time (from a millisecond to a second). Importantly, it may operate independent of conceptual knowledge (Cant et al., 2005). The second is devoted to the grasp-to-use process.t is a left-lateralized system, and it is located in the inferior parietal lobule. It employs conceptual knowledge concerning the functional use of objects and, in contrast to the first system, it maintains the information for a long time.

This neural organization was explored in greater depth some years later by Buxbaum and Kalénine (2010; 2017). They developed a specific model, the Two Action Systems (2AS), that was the result of the model proposed by Rothi et al. (1991) on behavioural dissociation in apraxia, and the neuroscientific literature on the functionality of the dorsal and ventral streams. Briefly, Rothi and collaborators observed that apraxic patients may replicate movements they may not recognize. This episode led the authors to propose a model that posited the existence of a direct and an indirect or semantic neural route. The direct route makes possible the transformation of visual information about objects into motor actions. The indirect or semantic one, instead, enables processing of input's conceptual meaning. According to the authors, the replication of the action in apraxic patients passes across the direct route bypassing the semantic one.

1.4.3. The Two Action Systems and the Two Action Systems Plus models

Buxbaum and Kalénine (2010) hypothesized the existence of two action systems which are neuroanatomically and functionally divided but that operate together: a structure system, based on the visual information for objects (e.g., size, shape, orientation), and the function system, related to the conceptual knowledge about the use of objects. According to the authors, the first is specialized for responding to the structural features of objects that have to be continually updated with respect to the eye, the hand, and the objects. Its responses are mostly consistent with prehensile actions, such as grasping, clenching, pinching. In addition, it is a system that possesses a very short sensorimotor memory for online processing and may be activated even when objects are not consciously recognized. The second, instead, is devoted to processing unchangeable features of actions associated with the use of objects. In contrast to the structure system, it maintains conceptual information for a long time in memory.

Regarding the two systems' complementary actions, a couple of studies were carried out by Buxbaum et al. (2003; 2006) with patients with ideomotor apraxia, i.e., a disorder of skilled movements linked with object use. The aim of the experiments of the first study (2003) was to investigate whether patients were able to match familiar objects and novel objects to hand-posture configurations. This intention was prompted by the studies conducted by Klatzky et al. (1987) who found that there exists a strict link between knowledge of hand postures and object knowledge. Buxbaum and colleagues asked participants to match familiar objects with appropriate hand postures. The results showed that the patients chose only structural responses that are associated with the structural features of familiar objects (e.g., they matched a pinch gesture, instead of a poke one, when a typewriter key was displayed), confirming a defective representation in memory of the association object-hand gesture for use. In contrast, the study revealed right structural responses when associating hand posture configurations with novel object shapes. This supported the fact that when an impairment of functional skills occurs, only the undamaged structural system (in dorso-dorsal stream) is employed to process responses during interaction with familiar objects.

In the second study (2006), an fMRI one, Buxbaum and colleagues tested the activation of the left lateralized system and the inferior parietal lobe during the recognition of hand-posture configurations for the functional use of objects in healthy participants. Three were the hand-posture conditions: a structural grasp with a clench or pinch, a functional prehension with a clench or pinch, and a functional movement with a poke or a palm-hand gesture (non- prehensile condition). From the data emerged a greater triggering of the left inferior frontal gyrus (IFG), inferior parietal lobule (IPL) and posterior superior temporal gyrus (STG) areas during the non-prehensile condition then the grasp one. Comparing prehensile and non-prehensile conditions, the latter was associated with greater triggering of the left inferior parietal lobule (IPL) only, supporting the importance of mediation between the ventral stream and the dorsal one when selecting non-prehensile gestures.

The 2AS model was adopted by Borghi and Riggio (2015) to link stable and variable affordances to the neural system. The similarities were described in terms of time course of object information, and their neural underpinnings. Specifically, they associated stable affordances with long-term information computed by the left-lateralized system, while variable affordances linked to online information processed by the bilateral system. Noting that the 2AS argues the left-lateralized system is a function system, the fact that in Borghi and Riggio’s view the stable affordances are not necessarily related to functional knowledge is significant. As regards neural representation, the authors suggested that the stable affordances are triggered in the ventro-dorsal route, it being the pathway dedicated to reaching and grasping gestures, whereas the variable affordances in the dorso-dorsal circuit are devoted to the short, online control of the action information.

In 2017, the 2AS model was revised by Buxbaum, who proposed the Two Action Systems Plus (2AS+) version. Basically, the author added the inferior frontal gyrus-supramarginal gyrus (IFG/SMG) to the two systems of the original version, the bilateral and the left-lateralized ones. This choice was made based on several recent investigations (e.g., Bi et al., 2015; Orban & Caruana, 2014) which found that also this area is involved in the selection and execution of tool actions.

1.4.4. The Three Action Systems model

Recently, Osiurak et al. (2017) considered the way researchers employ the notion of affordance. Specifically, starting from a review on the use of the term affordance in cognitive neuroscience based on three main principles, i.e., the action domain, the reference frame, and the cerebral system, they examined the most important interpretations of affordance in literature on tool use (e.g., microaffordances by Ellis and Tucker, 2007; manipulation and function affordance by Buxbaum and Kelénine, 2010; variable and stable affordance by Borghi and Riggio, 2015). Finally, they discussed the development of the three action-system model (3AS), according to which there is a clear separation between physical and neurocognitive systems.

As for the three main principles, regarding the action domain, the authors distinguished between that only require physical abilities, such as grabbing and transporting an object from one position to another, from actions that also involve cognitive skills such as using a computer. Within this latter category, they distinguished between the common use of tools, e.g., using a hammer with a nail, and the unusual use of tools, e.g., using a knife to drive a screw. Regarding the reference frame, the authors referred to the link between an agent and a tool, namely to the motor transmission from the agent (his hand) to a tool, and from the tool to an object (Goldenberg, 2009; 2014). In particular, they reported two interfaces discussed in a previous study (Osiurak and Badets, 2016): the first is hand-tool formed and the second tool-object based. The hand-tool interface is dependent on the agent's morphological characteristics and the tool, e.g., if a tool is too big, a baby cannot hold it, thus necessary compatibility between the agent and tool features, such as the size, is necessary. Similarly, the tool-object interface is dependent on both the physical features of the tool and the object involved in the interaction, e.g., a glass can break a peanut, but not a coconut. As discussed above, in this case the agent is not involved. Concerning this last principle, regarding the cerebral system, Osiurak et al. first referred to what already exists in neuroscience literature on affordance and tool use. Specifically, they described the three main cerebral roots involved in the motor process (i.e., the ventral, the ventro-dorsal, and the dorso-dorsal pathways) and tried to associate them with the two reference frames described above. To be even more specific, since the ventral system is responsible for object recognition and identification, and thus centred on the physical properties of objects such as shape, it is linked with the interface dependent of the tool characteristics; the dorso-dorsal system, which is dedicated to action control with short-term storage, is instead associated with hand-tool frame. No associations with the ventro-dorsal root were found.

As specified at the beginning, Osiurak et al., after examining the three principles described above, they considered the most important interpretations of affordance in literature on tool use. They started with Gibson (1977; 1979) who was the first to coin the term "affordance", they then reported Ellis and Tucker's definition of microaffordances (2007) and the distinction between manipulation and function affordance by Buxbaum and Kelénine (2010), they concluded with the variable and stable affordance proposed by Borghi and Riggio (2015) (see the previous section).

In line with the 3AS model, affordances are the result of three potential relationships that can exist between us and the environment; they are all justified at a physical level, i.e., the affordances, the mechanical actions, and the environmental features. Specifically, recalling the three main principles described at the beginning, Osiurak et al. considered affordances as being the result of that the surrounding space suggests someone based on its biomechanical characteristics. These are thus dependent on the hand-tool action frame. In addition, they stated that affordances are not dependent on the goal, since the intention to act started, anyway, at the physical level when an object is reached and moved. They concluded with this definition: "An affordance is an animal-relative, biomechanical property specifying an action possibility within a body/hand-centered frame of reference. Affordances correspond to a description of this possibility at a physical but not at a neurocognitive level. At the neurocognitive level, the issue is to understand how an animal can perceive affordances (i.e., affordance perception)." (Osiurak et al., 2017, p. 410).

1.5. Actions related to objects. Theoretical Summary

The last twenty years have seen the spread of behavioural and neurological studies investigating the mechanisms underlying perceptual processes in human cognition. The most influential theoretical approach is the embodied cognition view, according to which cognition is grounded in perception and action through a body interacting with its environment. Within this framework, the notion of affordance has been studied extensively since it implicates both perceptual and motor systems. Gibson’s renowned definition of affordances describes them as visual properties the environment gives us. They come from surfaces and substances, but above all from objects. Depending on objects’ physical properties, on the condition of our body, and on our goals, different types of affordances may be perceived: microaffordances, stable, canonical and variable ones, volumetric/structural and functional ones, multiple ones, broken ones, dangerous ones, social ones. The perspective on cognition as the outcome of our simulating previous experiences, has increased scientific interest in the neural networks involved in visual processing. Originally, two visual processing routes were thought to be implicated in human’s perception of visual information: the dorsal and the ventral streams. Further anatomical and neuropsychological studies indicated the presence of two additional routes within the dorsal system, i.e., the dorso-dorsal and the ventro-dorsal circuits; the first being devoted to the control of the online process during an action’s execution; the second being designated for recognition of actions performed by other people and of the location where they are performed. As regards structural and functional information processing, a bilateral system was assigned to the first information, a left-lateralized stream to the second.

As this first overview suggests, the present dissertation adopts an embodied and grounded cognition perspective, and it focuses on different kinds of affordances elicited by objects. Specifically, as shown in the experimental section, it explores the distinction between familiar and non-familiar objects' structural properties and functional information from a developmental point of view, since, to the best of our knowledge, evidence insofar comes exclusively from adults' interaction with familiar objects.

While in this first chapter, the attention is on action responses which are related to affordances, in the next chapter, the link between these and language, with particular emphasis on developmental literature, will deal with.

CHAPTER 2

AFFORDANCES AND LANGUAGE

2.1. What are concepts? Theories and beliefs

Murphy (2002) defines concepts as being the key ingredients of our thought through which we build new knowledge. He characterizes them as a sort of glue that holds together past, present, and future experiences. In other words, through concepts we can understand and organize the world around us: we will be able to know how to use objects, how to interact with others, how to move in space (Caruana & Borghi, 2016).

Over the years, scientists from different research fields (anthropology, philosophy, psychology, linguistics, neurosciences, and artificial intelligence) have developed several theories on concepts and there has been no lack of controversy among them. For example, as regards concept formation, there are researchers who believe that concepts are innate (e.g. Fodor, 1975) and researchers who claim that concepts are formed during development through experience (e.g., Mandler 2004; 2008; Barsalou, 1999; 2008 for two different interpretations). Here we will support the latter interpretation but with particular focus on the perspective of a grounded and situated cognition, according to which concepts emerge from situational elements, such as agents, objects, actions and internal states, even if these are simulated, i.e. re-enacted in our brain (Barsalou, 2008; 2018). Specifically, concepts entail reactivation of the neural pattern that occurs when we experience a given thing. For instance, the concept "fork" will be formed by the reactivation of the neural pattern that is activated when we experience it, e.g., when we eat, but also when we see someone using it. Concepts are thus based on perception, motor information, actions, and emotions: hence, they are aimed at acting (Nicoletti & Borghi, 2007).

The next paragraph provides a short overview of some of the most influential theories on concepts, with particular focus on concepts related to objects.

2.1.1. From the Classical Theory, across the Prototype and Exemplar accounts, to the Frames model

Elaborated by Aristotle in ancient Greek times, the Classical Theory is the oldest existing theory. Over the years, it was adopted by many scholars and in cognitive psychology it was the dominant approach until the second half of the twentieth century.

The basic assumption of the classical approach sees concepts or categories (indistinguishable terms in cognitive psychology) as the necessary and sufficient object features (Smith & Medin, 1981; 2013). Moreover, it distinguishes between the extension and the intension of a class, namely between all possible occurrences of a class of item and the underlying specific rule (Smith & Colunga, 2012). Continuing with the concept of "fork", its extension is all kinds of forks; its intension is a tool with two or more prongs. Interestingly, as stated by Miller and Laird (1976), functional attributes are also included in the lists of features.

Despite initial consent among scholars, this account has been criticized for different reasons. The general criticism is that the classical approach is too reductionist in deciding which features are included in the one concept and which ones in the other. For example, what are the characteristics that define a concept? Even for a well-defined category, an object can be equivocally classified as a member of one and not of another category (Hampton, 1979; McCloskey & Glucksberg, 1978). A classic example is that of the concept bachelor by Margolis and Laurence (1999). According to the Classical Theory, the concept of bachelor consists of properties such as adult, man, male, unmarried. In this way, any male, adult and unmarried man can be considered a bachelor: even the Pope! There are then borderline cases for which it is difficult to assess membership in one category or another: is tomato a fruit or a vegetable? Is the penguin a fish or a bird? According to the exponents of the Classical Theory, this incompetence depends on the knowledge one possesses, but for critics this rebuttal was not enough.

Two theories replaced the classical approach: prototype theory and exemplar theory. Both focus on generalization by similarity; the second is more centred on a memory retrieval process (Smith & Medin, 1981; 2013; Brooks, 1987; Borghi, 1997; 2002; Smith & Colunga, 2012). Specifically, by the first account, concepts are not thought of as the sum of fixed properties, as deemed by the Classical Theory, but as properties that can vary and be organized based on a family resemblance, i.e., a similarity criterion (Wittgenstein, 1953). According to this criterion, the prototype is a set of properties which are more or less relevant. There are no necessary features, but features are associated with a category with more or less probability. The more relevant the properties, the more likely they are to appear in a given category. This principle is also linked to Armstrong and Gleitman's typicality effect (1983), which says the more typical an attribute is, the more it is considered to be within a category, remembering that the effect mostly depends on typical experiences, which that can vary across situations and across culture (Barsalou, 1987).

Typicality effects are also found in the second account, the exemplar account. Specifically, when someone experiences new instances, he connects these with representations of it already stored in memory, based on a typicality association.

Medin and Schaffer's experiment (1978) provided the first evidence to demonstrate the efficacy of the exemplar theory. The authors found that subjects associated an exemplar with a category more easily, the more similar it was to the exemplars of the category presented during the learning task.

The exemplar theory also has its limitations. Its most significant shortcoming had to do with the substantial cognitive process involved in storing exemplars and then recalling them to memory for comparison with new ones. Smith justified this by stating that not all exemplars are stored in memory, but only the salient and the representative ones (Smith & Medin, 1981). In addition, in recalling exemplars stored in memory to compare with new ones, only the similar ones are evoked.

Subsequently, researchers suggested the guide for categorization is comprised of theories and beliefs, rather than personal experiences (Keil, 1992; 1994; Sloman, 1997). This explanation, mostly known as theory-theory, emphasizes the existence of general naïve and intuitive principles that establish whether an instance has properties which are relevant to being a member of a given category or not (Carey, 1985; Gelman & Bloom, 2000; Gelman, 2003). According to this, a "bat" might be seen as belonging to the class of birds because it has wings and flies, but it is a mistaken belief. The example of an animal is opportune due to the fact that a study revealed that this account works better with natural instances than artifacts (Gelman & Coley, 1990). Although several pieces of evidence which support this approach have been collected (Keil, 1992; Gelman &

Markman, 1987; Murphy & Medin, 1985), many researchers have criticized it strongly, finding fault with the non-definition of the term "theory", i.e., whether it is intended as a personal belief or as a shared theory (e.g., Borghi, 1997).

Barsalou’s frames model (1992b; 1993a) combines all the previous theories and goes beyond their limits. This model factors in all the features from the classical approach, all prototypes and exemplars, and all the personal theories; in addition, it includes spatial and temporal configuration, causal relations, and environmental constraints such as cultural conventions, which are considered and hierarchically organized.

According to Barsalou, frames represent all kinds of categories, including objects, locations, physical and mental situations. The main components of a frame are an attributes-values set (a), structural invariants (b), and constraints (c). Specifically, the author described an attribute (a) “as a concept that describes an aspect of at least some category members” (Barsalou, 1992, p. 30). It is important to note that, to be defined as such, an attribute must not be considered in isolation, but it must be associated with another aspect, otherwise it remains only a concept. Values, instead, are “subordinate concepts of an attribute” (p. 31). They consist of additional information that makes the concept more specific. Similarly, values can become attributes and create sorts of hierarchical attribute-value relations. For example, “leg” and “tail” are attributes of the concept “dog”; “short” and “long” are values of the attributes “leg” and “tail”; “short” and “long” may become attributes and have “four” and “black” as values. With structural invariants (b), Barsalou indicates the stable relationships among the attributes of a concept. The relationships may be spatial, e.g., the relation between the “roof” and the “window” in the frame “house”; temporal, e.g., the relation between “washing” and “drying” in the frame “having a shower”; causal, e.g., the relation between “sowing” and “watering” in the frame “cultivation”; intentional, e.g., the relation between “reason” and “attack” in the frame “killing”. Since attributes and values of frames are interrelated, the presence of a value or an attribute in one frame constrains all others (c). Moreover, constraints may be imposed by the context or by cultural conventions. For example, in the frame “travelling”, the traffic may represent a limit on driving speed.

As discussed, frames organize information in a hierarchical way, giving rise to taxonomic levels of categorization, which are described below.

2.2. How object categorization is organized. The hierarchical model

To understand how categorization is organized, we need to go back to the late 1970s when a group of psychologists (Rosch et al., 1976) demonstrated that humans classify categories, i.e., “the number of objects which are considered equivalent” (p. 383), in taxonomic levels. According to Rosch and colleagues, taxonomies are hierarchical systems in which concepts are related to each other by a class inclusion criterion: the more inclusive a class is, the more general it is. Thus, the concept “animal” is more inclusive than the concept “monkey” which, in turn, is more inclusive than the concept “orangutan” (a sort of Linneian taxonomy). In terms of cognitive economy, this hierarchical structure is efficient, because it organizes the information under a single level, the highest one, which makes recalling all the other information located at the lower levels possible.

The hierarchical levels of a Linnaean taxonomy reach up to five or more levels. Rosch and collaborators reduce and divide the categorization of objects into three hierarchical levels: superordinate, basic, and subordinate level (going from more- to less-inclusive). Here is an example: “kitchen utensil" is the superordinate of "fork" that is the basic of the subordinate "dessert fork". In addition, the authors stressed that, among the three levels, the basic one is the most employed by adults during object categorizations, and the first used by children in language development.

The criteria adopted to distinguish the levels of inclusion are different. Three are the most dominant: the linguistic, structural, and content-based. The first criterion entails considering the linguistic form of nouns found at different levels. In this regard, Murphy and Smith (1982) showed that basic-level nouns are shorter and more familiar terms than subordinate ones, which are long, less familiar, and sometimes compound terms. The second criterion refers to the type of information concepts provide. In this respect, Rosch and colleagues (1976) assumed that basic-level concepts are both distinctive and informative; superordinate level concepts, instead, are more distinctive and less informative; subordinate ones are less distinctive but more informative. These aspects were measured in terms of cue validity, i.e., the probability that an attribute characterizes a category. The more the frequency of an attribute is high for a certain category, the higher is the cue validity. The last criterion is not based on the terms used to refer to the concepts, but on the content of concepts. According to Lassaline and associates (1992), concepts have distinctive aspects at each specific hierarchical level. Specifically, attributes of basic-level concepts have the same shape and the same component parts, and therefore they induce the same motor response (Rosch et al., 1976; Tversky and Hemenway, 1984), e.g., all mugs are gripped by a handle. In addition, as emphasized by Biederman (1987), object concepts at the basic level are perceived immediately since their identification occurs through the recognition of the parts that compose it. Subordinate concepts, instead, are different from basic ones, because they are characterized by secondary properties, such as texture and colour, which are perceived later.

Distinctions among the levels of concept categorization may also be associated with the differentiation between primary and secondary categorization proposed by Barsalou (1991). With primary categorization the author means the initial extraction of information from an entity, which includes features of its physical structure, e.g., shape, parts, location. The secondary categorization, instead, extracts information relating to functional properties of an object, and it is a process which follows primary categorization. For instance, when you categorize “a cup” as “a cup” or “a teacup”, you operate a primary categorization; when you categorize it as “a utensil to drink tea”, you operate a secondary categorization.

This section has examined how concepts are organized; the next section explores Rosch and colleagues’ three hierarchical levels of categorization (1976), superordinate, basic, and subordinate, and their implication in developmental research.

2.2.1. Basic, subordinate, and superordinate concepts. Evidence from infancy and adulthood

As seen in the previous paragraph, the hierarchical model of concept categorization consists of three levels of concepts: the most general is the superordinate concept, followed by the basic concept, and the most specific is the subordinate concept (Rosch et al., 1976).

Superordinate concepts include the most general properties, they are usually expressed with collective and countable names (Wisniewski et al., 1996), and they vary depending on a person's level of expertise (Honeck & Firment, 1989). In addition, according to Tversky (1989), it is categorization based on functional elements, in contrast to the basic level which is mainly based on perceptual elements (Markman et al., 1980, Barsalou, 1992b). In fact, among the most important properties of the basic level are those related to the parts and to the shape of objects (RBC, Recognition By Components, Bierderman, 1987). Inferior properties such as the colour, material and texture of objects, are instead typical of the subordinate level of categorization, in addition to a higher production of compound names (Murphy & Smith, 1982). Interestingly, as seen previously, the relevance of perceptual information, such as the structure of an object, or the relevance of function-related information are distinct from Barsalou (1991) in primary and secondary categorization. Thus, basic- and subordinate level-categories belong to primary categorization; superordinate ones to secondary categorization.

The primacy of one level over another has been studied by several researchers. Studies have generally been conducted on babies and young children, but also on adults, since infancy until late childhood is the period when novel instances regarding objects, people, and events are acquired (Rosch et al., 1976; Bornstein, 1984; Rakison & Oakes, 2003; Bornstein & Arterberry, 2010). A first view sequenced acquisition of categorization level in this order: basic, superordinate, and subordinate. The basic level-categories are the first and most-easily acquired, and the most used by adults (Rosch et al., 1976). Between ages 4 and 5, there is a transition from the basic- to the superordinate-level categories (Markman & Callanan, 1983). The subordinate one is the last to be formed over the years (Mervis & Crisafi, 1982).

Evidence confirming the dominance of the basic level, for example, comes from Jolicoeur and colleagues (1984) with studies of undergraduate and high school students. They indicated that in categorization tasks with single, isolated objects images, objects were identified first with names at a basic level. Instead, when objects were displayed as part of a scene or as a group, identifications at a basic level decreased preferring categorization at the superordinate level (Murphy and Wisniewsky, 1989). The dominance of categorization at a basic level is also found in categorization of environmental scenes, events, and people. Tversky and Hemenway (1983) demonstrated, in fact, that the adults in their study preferred to describe objects embedded in spatial contexts with terms such as beach, mountains, home, school. On the other hand, Rifkin's exploration of categorization applied to events (1985) identified the basic level of abstraction as being the most frequent level in the study results. In fact, subjects listed more attributes for basic categories than for superordinate and subordinate categories. Cantor and Mischel (1979) also identified the basic level of abstraction as being dominant in the nature of categories related to personality types.

Another point of view, which currently enjoys support, do not see basic-level categories as being the first kind of conceptual categories to be developed. Several researchers (Mandler & Bauer, 1988; Mandler, 1992a; 1992b; 1993; Mandler & McDonough, 1993; Mandler, 2008; Bornstein & Arterberry, 2010; Shylaja & Manjula, 2016) showed that children use superordinate categories in a spontaneous way as early as the first year of life; later, they categorize at a basic level; even later at a subordinate one.

2.3. Concept combination in children and adults. Thematic, partonomic and taxonomic relationships

Concepts, being hierarchically organized, do not operate in isolation but rather in an inclusive manner. The way they combine with one another generates different types of relationships; the most investigated of these were the thematic, the partonomic and the taxonomic one.

Object concepts are thematically related when they are co-associated with events, space, time, objects, and agents (Markman 1981; 1989; Lucariello et al., 1992; Lin & Murphy, 2001; Lawson et al., 2017). For each of these occurrences, the thematic relationship acquires a specific connotation (Lin & Murphy, 2001). So there are various cases: spatial thematic relations, e.g., the fork is on the kitchen board, when the object concept's context is indicated; temporal thematic relations, e.g., I usually use the fork and a knife at dinner, when the object concept's temporal reference is related is specified; action thematic relations, e.g., I roll spaghetti", when a potential action of the referent could do is included; functional thematic relations, e.g., fork is used to eat, when the object concept's function is expressed; agent thematic relations, e.g., my mum always use it, when the referent of the object concept is indicated; and causal thematic relations, e.g. "this sharp part of the fork pricked my finger", when a causal effect is described. All kinds of thematic relationships are called ontological, because they represent the necessary conditions for interaction in the world of objects (Barsalou & Billman, 1989; Borghi, 1997). Recently, Barsalou and colleagues (2018), according to grounded and situated perspective, also added internal states such as emotion and motivation.

Partonomic or meronymic relationships are also ontological and they refer to part–whole associations. They can vary depending on whether the parts are essential or optional (Pribbenow, 2002), whether they have the same function, they are separable, they have the same texture (Winston et al., 1987; Chaffin et al., 1988; Chaffin, 1992). It is interesting to note that Tversky (1989) suggested that this kind of relation facilitates the transition from a perceptual to a functional categorization since the function of parts may make deducing the function of a whole object possible.

Finally, concepts are taxonomically related when all hierarchical levels occur. More specifically, taxonomic relations share similar perceptual and functional features, and are represented in conceptual hierarchies from more- to lesser- inclusive levels or vice versa (Borghi & Caramelli, 2003; Sass et al., 2009; Mirman, 2017).

The primacy of one relationship over another has also been studied, especially in developmental research. Most of the evidence suggested that children, primarily pre-schoolers, use more thematic relations than taxonomic ones (Markman & Callanan, 1983) because, according to Piaget and Vygotskij, young children are unable to form taxonomical classes (Lin & Murphy, 2001). Between ages 4 and 8, there is a developmental shift from the thematic to taxonomic level or in other words there is a shift from perceptual to more conceptual categories (Markman 1981; 1989; Carey, 1985; Jones & Smith, 1993; Sheya & Smith, 2006). An alternative explanation is widely shared: there is a coexistence between thematic and taxonomic relationships starting in the early stages of development (Bauer & Mandler, 1989; Osborne & Calhoun, 1998). Thus, even young children are able to make use of taxonomic categories. A later study where children aged 5, 8, and 10 exceeded in thematic relationships over taxonomic ones, is in contrast with the thematic-to-taxonomic shift. Interestingly, the same study offered an analysis of thematic categories, showing that children aged 5 years perform more functional and temporal relationships, whereas in older children spatial ones come out more often (Borghi & Caramelli, 2003). Studies on adults revealed that they can easily categorize objects both thematically and taxonomically (Estes et al., 2011), with a higher occurrence rate for taxonomic relationships (Tare & Gelman, 2010). However, a more recent study on adults (Lawson et al., 2017) found that they tend to sort objects more thematically than taxonomically, in support of Murphy's findings (2001; 2002) which suggested that adults do not reveal a strong inclination for taxonomical categorization, sorting stimuli more in a thematical way.

Experiments on partonomic relations are not abundant. The most interesting ones, and the most pertinent for this dissertation, showed that children (4-6-8-10 year-olds), during a free production task, counted more parts if the stimulus was a picture rather than a noun. In addition, the parts were relevant from both structural and functional information, similar to adults (Tversky, 1989; Borghi 1997).

2.3.1. Correlations between properties and roles. Evidence from children

Other interesting kinds of concept combinations worth mentioning have been proposed by Smith and Colunga (2012). In general, the authors focused on perceptual and conceptual knowledge in young children, with particular attention given to the recognition of novel instances. The authors introduced three kinds of associations: property-property, property-role, and role-role correlations.

Property-property correlations concern the importance of perceptual properties such as shape or other features (e.g., an animal's eyes or mouth) which allow one to recognize an object easily. Clusters of properties which are relevant and typical of a class of instances co-occur; this helps categorization as well as recognition of novel objects because they present those specific and typical perceptual properties. Thus, children who are presented with pictures of animals or vehicles can readily make inferences starting from properties such as head or eyes and wheels, and can categorize at a superordinate level, e.g., "animal"; "vehicle" (Rakison & Butterworth, 1998b; Rakison, 2003). For instance, "the cow is an animal because it has eyes and horns"; "the bike is a vehicle because it has wheels".

The second kind of correlation concerns the co-occurrence of physical properties and functional information (e.g., "chair is used for sitting" or "things with back are used for sitting"). According to some authors, (Mervis & Mervis, 1988; Bates et al., 1988) parents play a crucial role in the categorizing children do during development because parents simulate the actions of objects (e.g., a toy horse that walks and eats) during play. In this way, children easily learn the correlation between "legs" and the action of "walking", and the correlation between "mouth" and "eating". This correlation is then useful for new instances of learning, in particular for the acquisition of new words: Goodman et al. (1998) found that, saying a new word along with a verb that express a familiar action (such as "to eat"), children categorize that word according to the class of instances that co-occurs with the action "eating". For example, "wug eats", therefore "wug is an animal" (Smith & Colunga, 2012).

The last relationship is that among functional properties. For example, "animals that eat also sleep". It deals with associations between roles that are not linked with perceptual structural features. Little evidence has been collected on how children link different conceptual functions. The most interesting reveals that overall, children are strongly tied to perceptual properties and that only in specific contexts are they able to find relationships among different roles. Examples of specific contexts in this regard include verbal reasoning tasks, i.e., tasks that assess an individual's abilities such as understanding, making sense of things, applying logic, or categorizing animate and inanimate things. For instance, regarding the context of the verbal reasoning task, Keil (1979) finds that older pre-schoolers are able to systematically associate the right predicates with their relative subjects, suggesting that they know how to generalize reality using relationships to be found in function information. In a similar way, Booth and Waxman (2002b) observe in a study that three-year-old children could categorize objects as animate when the experimenter told them that objects were associated with functions such as being hungry, being happy, having parents, smiling, and so on; and as inanimate when the experimenter told them that objects were made, were bought, were static. This result, like the previous one, confirms that children have knowledge about the categorization of specific object categories and that they categorize based on co-occurring of functional properties.

2.4. The importance of structural and functional information in object concept categorization

Previous sections of this chapter have shown how, during object concept categorization, two properties invite heightened attention: structural or volumetric information and function knowledge (Buxbaum et al., 2000; Bub et al., 2008). As described in the first chapter, the former is linked to structural features and the gestures useful to hold and use objects, e.g., "a fork is held in the hand to obtain food from a dish". The latter one exclusively concerns the use of an object, e.g., "the fork is used to eat".

Little is known about contemporaneous activation of these two types of information in children and adults. The earliest empirical evidence was collected to investigate the distinction between living and non-living categories in patients with brain lesions (Warrington & Shallice, 1984). Results showed that functional features were more relevant than visual ones. A more recent study (Garcea & Mahon, 2012) with healthy adults demonstrated that participants produced faster reaction times when accessing function information than when manipulating features.

The unique to our knowledge and the more current developmental study on 8-9-10 year-old children and adults (Collette et al., 2016) revealed that, during a task of naming familiar objects, children preferred manipulation knowledge more than adults did, the latter favouring functional knowledge. Between 8 and 10 years of age a slight decrease in structural features occurred, whereas no difference between 10-year-olds and adults was evident.

2.5. Where object concepts are rooted. The brain localization

The language process has also been studied in terms of brain representations (Bidet-Ildei et al. 2020 for a recent review). According to the embodied theory, language is rooted in the same neural areas which are activated during movement (Gallese & Lakoff, 2005; Gallese, 2008; Glenberg & Gallese, 2012). Thus, when we read a sentence referring to the action on a manoeuvrable object, our motor system is activated, specifically in the dorsal premotor cortex, posterior inferior parietal sulcus, medial fusiform gyrus, and occipital temporal cortex (Ramsey et al., 2013; Horoufchin et al., 2018; Bidet-Ildei et al. 2020).

Two distinctive brain routes have been found to differentiate online actions directed at emphasizing structural from functional information: a bilateral dorso-dorsal system subordinated to the first type of features, while a left-lateralized inferior ventro-dorsal stream devoted to the second ones (Buxbaum, 2001; Buxbaum & Kalenine, 2010; Binkowfski & Buxbaum, 2013).

The neural basis of hierarchical levels of categorization and relationships have also been explored. Overall, evidence from neuropsychological and neuroimaging studies documented the brain activation of thematically and taxonomic categorizations into two distinct areas: in the left posterior temporoparietal cortex when thematic relations occur, and in the left anterior temporal lobe area when categorization is taxonomic (Kalénine, 2009; Kalénine & Buxbaum, 2010; Schwartz et al., 2011; Kalénine and Buxbaum, 2016). Kalénine et al. (2009), in an fMRI study, presented adult participants with three object images, where one represented the target image; participants had to associate one of the two remaining imageswith the target. The pictures could be thematically associated, e.g., screwdriver-screw, or taxonomically associated, e.g., screwdriver-wrench. The study showed that the two kinds of knowledge relationships involved both posterior and anterior areas and, specifically, that thematic relationships triggered the bilateral posterior temporoparietal cortex, while the taxonomic relations activated bilateral occipital areas.

Using Voxel-based Lesion-Sympton Mapping (VLSM) analysis, Schwartz et al. (2011), explored the brain areas devoted to thematic and taxonomic semantic errors during a picture naming task in aphasic patients. Their work revealed that thematic errors, e.g., apple-warm, were linked with lesions of the temporoparietal junction, whereas taxonomic errors, e.g., apple-pear, were linked with lesions of the anterior temporal pole.

Interestingly, Kalénine et al. (2009), in addition to their previously mentioned results, showed that the processing of conceptual relationships of thematic and taxonomic type depended on object categories. Specifically, the authors carried out a behavioural and an fMRI experiment which adopted the same picture matching task, i.e., they asked participants to categorize, thematically or taxonomically, four object categories, namely, natural objects, artifacts, manoeuvrable objects, and non- manoeuvrable objects. The neuroimaging results showed that thematic relationships were faster for manoeuvrable than they were for non- manoeuvrable artifact objects, with activation of the left posterior temporoparietal cortex, while taxonomic relations were quicker for non- manoeuvrable natural objects, with activation of the bilateral visual areas. In contrast, behavioural data revealed that thematic relations were faster for manipulable artifacts objects, while taxonomic relations were quicker only for natural objects.

2.6. Concepts related to objects. Theoretical Conclusions

As this overview suggests, much evidence has been collected regarding the link between the language related to object and the sensorimotor system. Much is known about categorization levels (basic, superordinate, subordinate) and conceptual relations (thematic, partonomic, taxonomic) of familiar object categorization in infants, older children, and adults. On the other hand, little has been collected about contemporaneous activation of the two important knowledge relating objects, i.e., structural and functional information, across developmental stages.

Considering what the literature reveals, reported in this chapter, in the second part of this dissertation (Chapter 7) the empirical study aimed at investigating the kind of knowledge elicited while manipulating familiar and non-familiar objects by children, preadolescents and adults will be examined. Specifically, knowledge will be analysed in terms of categorization level (basic vs. superordinate vs. subordinate), conceptual relations (thematic vs. partonomic vs. taxonomic) and primacy of object information (structural vs. function knowledge).

PART II

EXPERIMENTAL EVIDENCE

CHAPTER 3

STUDY 1: THE FAMILIAR AND NON-FAMILIAR STIMULI (FANS) DATABASE. A COLLECTION OF EVERYDAY OBJECTS CLASSIFIED BY CHILDREN AND ADULTS[1]

Introduction

The selection of the stimuli is a critical aspect of behavioral research on human cognition. In order to investigate cognitive processes (e.g., perception, learning, and language), to better develop different tasks, and to detect any differences in behavioral performances, researchers make use of different types of stimuli. For instance, many experimental designs make use of everyday objects as stimuli, or of pictures, sounds, and words (Jax & Buxbaum, 2013; 2010; Hunnius & Bekkering, 2010; Borghi & Riggio, 2009; Bradley & Lang, 2000; Samuelson & Smith, 2005; Smith, 2003). In this study the attention is focused on familiar and non-familiar everyday objects.

Generally, researchers choose their stimuli by consulting existing databases (e.g., Citron et al., 2014; Laws, 1999), selecting known objects and creating their own norms (e.g., Borghi & Riggio, 2009), using their intuitive judgments without a previous investigation (as stated by Migo et al., 2013), or creating specific objects appropriate to their purpose (Samuelson & Smith, 2005; Smith, 2003). Several available databases classify known objects according to their image, name, visual complexity, familiarity, mental image, and manipulability. In 1980 Snodgrass and Vanderwart published the first

[1] A revised version of this chapter has been submitted to the peer-reviewed scientific *Journal of Cognition and Development*.

normative database of visual stimuli. The earliest version proposed 260 black and white line drawings of objects, animals, vehicles, body parts, and symbolic representations standardized on name and image agreement, familiarity, and visual complexity by 219 adult (students) native English speaker participants. In the following version, these norms were integrated with norms obtained from 7-10-year-olds (Berman, Friedman, Hamberger, Snodgrass, 1989) and 5-6-year-olds (Cycowicz et al., 1997), increasing the collection to 400 stimuli. In later years, norming data for the same (or some of these) stimuli were also collected in many different languages (e.g., French, Dutch, German, Italian, Russian, Spanish, Swedish, Brazilian, Chinese, Canadian, Icelandic, Portuguese) in order to understand how cultural and linguistic differences may influence object representation (Sirois et al., 2006; Yoon et al., 2004; Miranda et al., 2004; Kremin et al. 2003; Pompeia et al., 2001; 2003; Pind et al., 2000; Alario and Ferrand, 1999; Sanfeliu & Fernandez, 1996). Since the Snodgrass and Vanderwart's database contains only schematic representations, it was revisited in French by comparing the data to stimuli with the same shapes but with added gray-level texture surface details and color (Rossion & Pourtois, 2004). According to the results of the study, the addition of this information facilitated the recognition of objects in terms of naming accuracy and speeded correct response times. Later, these findings were confirmed by Salmon and colleagues (2014), who performed a behavioral experiment with English undergraduate students. Their results showed that photographs of manipulable objects elicited faster naming than line-drawings, likely because photographs trigger more embodied representations. The first color photos database was presented by Viggiano and colleagues (2004), with the purpose of selecting more ecological stimuli. It includes 174 pictures in black-and-white, colored, and spatially filtered versions; it was tested on two adults' samples, one of English and one of Italian speakers. Similarly, in 2008, Adlington and collaborators proposed the Hatfield Image Test (HIT), a corpus of 147 high-quality photographic color images tested on a sample of English adults. Later, Brodeur and colleagues created the Bank of Standardized Stimuli (BOSS) in two versions (Brodeur et al., 2010; 2014). The first version of BOSS (2010) presented 480 photos available in different formats (colored, in grayscale, blurred, scrambled, and line-draw) and standardized both for the norms of Snodgrass and Vanderwart (1980) and for two new ones (i.e., the category to which the objects belong to, e.g., food, kitchen utensils, living, non-living objects, and the manipulability, i.e., how the action associated with an object is easy to mime). The second version of BOSS (2014) included 930 new colored photos not present in the original BOSS. Participants in both studies were English speaker adults. Similarly to Brodeur and colleagues (2010), Salmon and collaborators (2010) provided norms for familiarity (high and low), age of acquisition, and grasping and functional use for over 320 black and-white objects with the aim to capture relevant dimensions of object manipulability. The norms were obtained from a sample of adult English speakers. In recent years, two other databases of known objects were proposed. The first is called AfNet: The Affordance Network (Varadarajan & Vincze, 2013), and classifies objects in terms of visual perception features, such as shape (e.g., spherical, cylindrical, flat), color (e.g., white, silver, gold), material (e.g., disposable or durable material), functionality (e.g., contain-ability, support-ability). It is a classification of 250 stimuli useful for tasks related to visual perception and object manipulation, and it includes common household objects (e.g., cup, plug, screwdriver, etc.). The other one was constructed by Duñabeitia et al.

(2018). It is named MultiPic and presents a new set of 750 colored pictures of concrete concepts normed in six different European languages (British English, Spanish, French, Dutch, Italian, and German). Images were tested on adults who were native speakers of the target languages.

The databases described so far include known objects. However, not all studies make use of known objects: other studies prefer the selection of novel and non-familiar stimuli, i.e., stimuli not known by participants who participate in the experiments. Novel and non-familiar stimuli are employed mainly in studies on children, e.g., to test how they acquire new categories and new words (Smith, 2003) and in studies on adults to be certain that no previous knowledge influences their performance. In general, novelty is defined as the quality of being new and unusual, and as one of the major determining factors directing attention (APA Dictionary of Psychology, 2020). It stimulates our interest, motivation, and curiosity, representing in this way a determinant of exploratory behavior (Berlyne, 2000). Therefore, the importance of this variable becomes crucial, for example, in word learning tasks (e.g., Horst & Samuelson, 2008; Yu & Smith, 2007), categorization studies (e.g., Homa et al., 2011; Bornstein & Mash, 2010; Smith & Minda, 2002), object recognition (Smith, 2003; Hummel, 2000), and object manipulation tasks, where participants must extrapolate information from what they have not seen before, and use it to accomplish the task.

To our knowledge, databases of novel and non-familiar objects are a few. Recently, a set of 64 novel object images has been published: the NOUN Database. This database, tested by a sample of undergraduate students, offers a collection of novel objects images, mainly toys, normalized for novelty, similarity, and classifies these into basic and global level categories (Horst & Hout, 2016).

As this short overview suggests, most databases are based on the participation of adults and include familiar stimuli, while only few focuses on non-familiar stimuli. Norms by children were obtained only for the database of Snodgrass and Vanderwart (e.g., Berman et al., 1989; Cycowicz et al., 1997). For example, Berman and colleagues (1989) found that the judgments of familiarity of common objects (line drawings) are based primarily on information processing achieved before age seven and are modified a little after that. Later, Cycowicz et al. (1997) demonstrated that familiarity was lower in young children than in adults and claimed that the choice of age-appropriate stimuli is crucial to interpret age-related differences in cognitive functions unequivocally.

The FANS database differs from previous ones since it includes both familiar and non-familiar objects (colored 3D images), and it aims at verifying how object knowledge is modulated by age (from childhood to adulthood). Participants from 3 to 40 years old were asked whether they knew the objects, which was their name, their function (if they did not know the object, we asked which name and which function they might have), whether they have used them or seen somebody using them, and with which frequency. The idea was namely to consider the different ways in which preschoolers, schoolers, and adults, males and females, represent objects of different familiarity. Specifically, the hypotheses were: 1- as age increased, the level of familiarity and frequency of personal use of objects also rose; 2- children were more creative and older participants more intuitive in finding the names and the functions of the non-familiar objects: 3- younger participants would be less aware of their knowledge level and knowledge gaps than older ones. For example, children might be able to use and manipulate objects, even if they have not yet developed an awareness of their knowledge and might not know the object's name or the category it belongs to (Horst & Hout, 2016). In contrast, they might know and even be familiar with the name of an object without knowing how to use it.

Another major novelty of this database concerns the criteria adopted for object selection. Objects were chosen to consider both their visible structure and their invitations and constraints of use, in other words considering their affordances. Specifically, affordances were distinguished between structural and functional ones.

The notion of affordance, initially introduced by Gibson (1979), concerns the intrinsic and perceived properties of material things offered by the environment, allowing us to understand how to interact with them. For example, the affordances of an apple invite us to grasp and bring it to the mouth. According to Gibson, this information is directly perceived without the need to activate knowledge of a particular object. For example, it can tell us how to move an object, whether something can fit into its grooves, whether it has fixed or moving parts, and whether there could be potential constraints that limit action possibilities (Norman, 1997). The literature on object representation has taken inspiration from the ideas of Gibson, but it has also introduced many novelties (for recent reviews, see Osiurak et al., 2017; Sakreida et al., 2016; Borghi & Riggio, 2015; Thill et al., 2013). In this study, the most important distinction is that between structural properties and function knowledge. In this respect, some authors distinguished structural or volumetric and functional characteristics of objects (Bub et al., 2018; Pellicano et al., 2010; Bub et al., 2008). Volumetric characteristics are the visual information about objects such as the shape, size, and orientation; functional characteristics consist of conceptual information about objects' skillful use. In a similar vein, in the literature on semantic feature generation (e.g., McRae et al., 2005; Vinson & Vigliocco, 2008), the authors distinguish between functional features, referring to what an object is used for, and motoric ones, referring to how it moves. In this regard, much evidence from behavioral (e.g., Kalenine et al., 2014; Borghi et al., 2012; Jax & Buxbaum, 2010; Bub et al., 2008), as well as neuroimaging studies (e.g., Buxbaum et al., 2003; 2006; 2007; Jax & Rosenbaum 2007; 2009), has been collected. Interestingly, considering that object affordances can be associated with multiple graspable actions depending on the agent's goal (Ansuini et al., 2006; 2008), e.g., clench to grasp and move an object and poke to use it, Jax and Buxbaum (2010) performed a behavioral study to test the idea that there is a competition between structural and functional responses during action selection. Specifically, they found that structural responses are activated faster than functional actions. This result demonstrated that grasp responses require less time to initiate than use responses. Also, the neural basis underlying these two kinds of affordance differs. The structural information is more rooted in the dorso-dorsal system, while the functional one involves a ventrodorsal stream (e.g., Binkofski and Buxbaum, 2013; Young, 2006; Rizzolatti and Matelli, 2003).

In summary, both action and function information are crucial for manipulable object representations, and it is critical to provide a database aiming at selecting object stimuli. Therefore, here structural and functional properties and different graspable actions were considered in order to select the objects.

A critical property assessed in the literature of databases, and particularly those looking at objects, is the name agreement, i.e., the degree to which different people agree on a name for an image. Across the years, researchers have collected many norms on name agreement for familiar objects, for different populations and different age groups. In general, the name agreement is evidenced by two measures. The first one is the percentage of expected responses provided by individuals. For example, 90% of individuals tested on the picture of a cow said that the name of the depicted object was "cow". The second measure is the H statistics of the name agreement. The H value considers the number of alternates that have been given by subjects for a target picture. For the percentage measure, a higher number signifies greater name agreement. However, for the H measure, a lower number signifies greater name agreement; for example, when all subjects supply the same name, the value is 0. A higher value indicates that a greater number of alternative names was supplied. The common criterion used by several researchers (e.g., Snodgrass and Vanderwart, 1980, the first to use it; Alario and Ferrand, 1999; Kremin et al., 2003; Miranda et al., 2004; Adlington et al., 2008; Brodeur et al., 2010) for counting different instances of names of well-known objects among adults was extremely strict (e.g., abbreviated names or names with elaborations or qualifiers are considered different names). Despite its advantages, this criterion can be problematic when applied to a children's sample. A study conducted by Cycowicz and colleagues (1997) adopted this criterion on picture naming in young children. Their results revealed that the modal names produced by children did not always correspond to adults' modal names. Furthermore, children produced a larger number of alternatives, often wrong, names than adults. For this reason, Cannard and colleagues (2005) in a methodological contribution on name agreement in French children (3-8 years old) affirmed that the classical measures are not the most suitable for young children. They suggested to use less stringent accuracy criteria in judge children's answers, e.g., to consider correct also names with elaborations (e.g., polar bear instead of bear), or with abbreviations (e.g., télé instead of television). Things are even more complicated with studies on novel objects. The criterion adopted by the authors of the only published database of novel objects (Horst and Hout, 2016), was even less strict since it is very hard to agree on names when objects are not familiar. For instance, following Landau and colleagues' (1998) assumption, according to which in naming objects the most important component is the name, in their assessment, they did not include qualifiers and only considered the name they refer to. Then, they grouped synonyms to increase subjects' agreement. Finally, in choosing an agreement threshold, they considered that of 85% set by Samuelson and Smith (1999). In this study, the percentage of name agreement was measured by following the criteria adopted by Cannard and colleagues (2005) and by Horst and Hout (2016), since the sample includes young children and, among stimuli, there are non-familiar objects. Beyond measuring the name agreement, the degree of function agreement of each object was calculated. To the best of our knowledge, norms on function agreement have never been collected. Here this measure was considered crucial. Indeed, as the study on object manipulation (see Chapter 5) revealed, compared to preadolescents and adults, children are less bounded to functional fixedness (i.e., the tendency to perceive an object only in the way it is commonly used), when asked to provide functions of known objects. Specifically, the activation of structural and functional information across different age groups was investigated. Results revealed that children, compared to preadolescents and adults, interact with objects not only in the way they are commonly used but also in an alternative and creative manner, thus identifying novel object functions.

In conclusion, compared to previous databases, the present one includes both familiar and non-familiar objects belonging to various categories of everyday objects, selected based on their structural and functional features. Objects are arranged according to their familiarity, frequency of personal and observed use level (high, medium, and low), and name and function agreement. Italian participants of three age groups (preschoolers, schoolers, adults), males and females, evaluated the objects familiarity, and reported whether they had experienced them directly or observing other people. Participants also had to provide the object name and function, and name and function agreement were computed across participants. Overall, these measures allow to understand how knowledge of objects changes and improves across development.

Method

Participants

Participants were recruited online by email and social network in order to obtain different groups based on the age range (3-80 years old). A total of 215 Italian speakers from different regions of Italy voluntarily and anonymously took part in the online questionnaire (152 females, 25 left-handed). It was necessary to exclude 66 participants due to the following reasons: 54 participants did not complete the questionnaire; 12 older participants (from 40 to 80 years old) due to the low participation of peers that did not allow consideration of a last group of adults from 40 to 80 years. Therefore, the final sample was of 149 participants (94 females, 18 left-handed) divided as follows: group 1 – preschoolers (from 3 to 5 years old), 26 participants (11 females, four left-handed); group 2 – schoolers (from 6 to 16 years old), 51 participants (27 females, seven left-handed); group 3 – adults (from 17 to 40 years old), 72 participants (56 females, seven left-handed).

Participants were informed by email about (a) the aim of the survey, (b) the anonymity of their participation, (c) the need for parental participation for children from 3 to 10 years old in order to assure the reading and comprehension of the queries but not the help in answering, and (d) the freedom to interrupt their participation at any time and for any reason. According to the Ethic Committee of the University of Bologna, all the information provided via email was adequate to obtain informed consent which was given by the voluntary participation in the survey. Specifically, acquiring anonymous online data does not require participants to provide any personal information to avoid in any way tracing their identity. Similarly, consent to the processing of data is not needed, as legislated by the Regulation (EU) 2016/679. The study was approved by The Ethic Committee of the University of Bologna (Approval number: Prot. 78991, 8.6.2018).

Materials

Thirty colored 3D images of daily use objects with white backgrounds were used. These included four tools (e.g., screwdriver), four household articles (e.g., clothespin), ten kitchen utensils (e.g., fork), four leisure tools (e.g., whistle), four objects for personal care (e.g., cotton swab), and four office supplies (e.g., mouse).

Different structural features (Jax & Buxbaum, 2010) and tactile information were considered, i.e., the shape, the size, the material, and the texture. To classify the shape, AfNet criteria (Varadarajan & Vincze, 2013) were adopted. The shapes selected were: circular (one object: egg scissors); cylindrical (three objects: e.g. bottle); cuboid (one object: sponge); flat-concave (one object: wrench); prismatic (one object: metronome); spherical (one object: nebulizer); thin rectilinear (two objects: cotton swab, tie wrap); sharp tip (three objects: e.g. fork); thin strips (one object: hairpin); concave structure (four objects: e.g. tube holder); conic cavity (three objects: e.g. folding funnel); flat convexity (one object: mouse); ring (two objects: fruit peeler ring, thumb book holder); two connected structures (six objects: e.g. clothespin). The materials were: cotton (one object: cotton swab); iron (four objects: e.g. sieve); plastic (ten objects: e.g. bottle); plastic and iron (five objects: e.g. fruit cutter); plastic and steel (one object: nutcracker); rubber (one object: folding funnel); sponge (one object: sponge); steel (five objects: e.g. fork); wood and iron (one object: clothespin); wood and rubber (one object: plunger). The texture selected are: smooth (e.g., thumb book holder) or rough (sponge with abrasive side), soft (cotton swab) or hard (fork), matt (wrench) or glossy (sieve). As to the size, objects with small dimensions were mainly choose to facilitate their use in manipulative tasks.

Functional properties were distinguished between grasp and use posture (by referring to Jax & Buxbaum, 2010), e.g., clench and/or pinch grasp, and double grasp such as clench plus pinch and/or clench plus poke. Specifically, thirteen objects were associated with a clench grasp (e.g., screwdriver); eleven objects were linked to a pinch grasp (e.g., clothespin); five objects with a clench plus pinch grasp (e.g., padlock); one object with a clench plus poke grasp (mouse). In addition, since in this study familiar and non-familiar everyday objects were included and the aim was to detect the level of familiarity by asking the function of the objects besides the name and the frequency of use, the functional properties can be associated to the features that semantic feature generation literature calls functional and motoric properties.

To choose between familiar and non-familiar stimuli, the existing databases (BOSS, Brodeur et al., 2010; 2014; AfNet, Varadarajan & Vincze, 2012; NOUN, Horst & Hout, 2016) and the properties described above were consulted. Familiar objects were selected from the BOSS and AfNet databases. Non-familiar objects were found by searching on Internet. Non-familiar objects were not choosen from the NOUN database because it mainly proposes toys (e.g., dog toys, ball catcher, boomerang, etc.), while a more varied set of everyday stimuli was needed. Therefore, non-familiar stimuli were selected from the categories of tools, household articles, kitchen utensils, leisure tools, objects for personal care, and office supplies. Out of the thirty images of real objects, twenty-eight were taken from the Internet, while two were made with real 3-D objects. Adobe Photoshop was used to attenuate the areas of shade and make the image of these two photographs as clean as possible. The size of the 30 images was 180 pixels in width and in height. Objects were presented in a standardized (and not relative) size in the image. All images were saved as File JPG (Jpegs). Each image was assigned a random Q-number ID between 1-30 (e.g., Q1 for thumb book holder) to facilitate identification during the analysis. The list of the object images, names, category, structural properties, and actions referred to the functional use, the level of familiarity for all age groups (high, medium, low) and the percentage of familiarity for each one are presented in Table A1 in Appendix A.

Procedure

Participants were asked to take part in an online questionnaire (administered through Qualtrics software) available for PC and mobile devices, lasting approximately

30/45 minutes. Each participant saw the thirty images of daily use objects, one at a time, and was asked to answer the five written questions that follow:

1. Familiarity. *Do you know this object?* Participants were asked to click on the Yes or No button.

2. Naming. *If yes, what is it? / If no, try writing what it could be.* If participants have answered Yes to the previous question, then they were asked to write the name of the object. If participants answered No, they were asked to write the name it could have or to invent a name it might have.

3. Function. *If yes, what is it for? / If no, try writing what could it be for*. If participants answered Yes to the first question, then they were asked to write the function of the object. If they answered No, they were asked to write the function it could have or to invent a function it might have.

4. Using. *Did you use it personally or did you see someone use it?* Participants were asked to indicate whether they personally used the object or whether they had seen someone else use it.

5. Frequency of use. *How often? Never/rarely/sometimes/often/very often*. Participants were asked to indicate how frequently they used the object, or they had seen others use the objects. Two 5-point rating scales were used to rate both the personal use and the observed use, in which 0 indicated never and 4 indicated very often.

The second and the third questions (i.e., the naming and the function) were asked to determine whether participants really knew the name and the functions of the objects or whether there was a discrepancy between what they declared and their effective knowledge.

During the presentation of each of the five questions, the image of the object was always presented. Once the five responses for each object were typed, the image of the following object and the relative questions were displayed. During the questionnaire, the 30 objects images were presented in random order. Participants were allowed to return to the previous questions in order to change or complete the responses. All the responses were mandatory.

Note that the questions were wrote in a way easy to understand by younger children. Indeed, concepts such as familiarity and frequency of use, which 3-year-olds have not yet acquired, were not used. Moreover, parental participation for children from 3 to 10 years old assured their comprehension. Parents of children from 3 to 10 years old received specific instructions: they were asked to read the questions, assure the child's comprehension, avoid any help or suggested answers, and type precisely what they said. A preliminary check proved the reliability of this method.

Analysis

Coding Familiarity

Responses related to the question on object familiarity were coded using two different criteria. The first coding criterion did not take into account the answer given to the first question (Yes or No) and the eventual discrepancies with what participants later claimed on the name and function of the object. The second coding criterion allowed to evaluate the level of self-confidence, i.e., the trust in one’s judgment or intuition, while the first did not.

Criterion 1

For the first coding criterion, the answer given to the first question was not considered. Only the answers given to the naming and function questions were codified with a score between 0-2:

- 0, if participants gave wrong answers both to the naming and to the function questions;

- 1, if participants gave at least one correct answer, either to the question on the name or to the question on function;

- 2, if participants gave a correct answer both to the name and to the function question.

Notice that correct answer means the usual name and the canonical function of the object. The canonical function of known objects was checked through dictionaries. For example, the canonical function of a bottle is to contain water for drinking; the non-canonical function is to fill it with pebbles and use it as maraca.

A quantitative score, from 0 to 1,5, to four qualitative categories, i.e. Yes, No, Yes Alternative Answer (YesAA), No Intuitive Answer (NoIA), was assigned. See Criterion 2 below for a comprehensive description of the categories. The scores ranged from 0 (wrong answer) to 1,5 (right answer). The higher the number, the less the discrepancy between the yes/no response and the following naming and functional question:

- 1,5 to Yes: the participant correctly stated that s/he knew the name and function of the object;

- 1 to No Intuitive Answer (NoIA): the participant claimed s/he didn't know the objects but typed the correct name and function, but also only the correct function;

- 0,5 to No: the participant correctly stated that s/he knew neither the name nor the function of the object;

- 0 to Yes Alternative Answer (YesAA): the participant stated s/he knew an object, but s/he typed a wrong/creative/alternative response to both the name and function.

Each subject was assigned a familiarity score given by the sum of the scores obtained for each item. Note that in order to assign these scores not only whether the answers were correct or not were considered but also whether participants were aware of their knowledge or not. For both the Yes and No scores, there was no discrepancy between what participants believed to know and what they knew; a discrepancy was instead present for the Yes Alternative Answer (YesAA) and No Intuitive Answer (NoIA) categories.

Criterion 2

For the second coding criterion, the answer given to the first question (Yes or No) wass considered, and then it was codified according to the naming and to the function questions, assigning the response to one of four different categories: Yes, No, YesAA, NoIA.

- Yes, if participants answered Yes to the first question, and then they typed the correct name and the correct function. We also included the cases in which participants didn't remember/know the name and knew only the function;

- No, if participants answered No to the first question, and then they typed the wrong name and the wrong function;

- Yes Alternative Answer (YesAA), if participants answered Yes to the first question, and then typed a wrong/creative/alternative name and function;

- No Intuitive Answer (NoIA), if participants answered No to the first question, and then typed the correct function.

Both codes were checked by two persons. The percentage of agreement was 97%. Disagreements were solved after discussion with a third judge.

Coding Name agreement

The answers given to the naming question were coded to determine the percentage of the name agreement for each object, and for each age group. This measure was computed on the total of the right answers and the total of the given ones.

To determine the percentage of name agreement, the criteria adopted by Horst and Hout (2016) and by Cannard and colleagues (2005) that are less rigid than that widely used (e.g., by Snodgrass and Vanderwart, 1980) were followed. As anticipated in the introduction, these criteria were adopted since the sample also includes young children and that among stimuli, there are non-familiar objects. The choice was made also based on further considerations: a) languages have significant lexical variability, e.g., a single concept may be named in several different ways, b) research on children (Cycowicz et al. 1997; Cannard et al., 2005) revealed that children provide numerous alternative names, often wrong; c) it's not easy to agree on a single name when objects are not familiar (Horst & Hout, 2016). All these aspects led to: a) only consider right answers, namely those belonging to the Yes category (second coding criterion); b) consider answers such as "don't know the name" and "don't remember" in measuring the name agreement on the total of the given responses, avoiding to include them in the total of the right answers; c) correct and consider misspellings (Horst & Hout, 2016); d) only include the first name when multiple ones were typed (Snodgrass & Vanderwart, 1980); e) not consider qualifiers (Landau et al., 1998), e.g., spugna abrasiva (abrasive sponge in English) instead of spugna (sponge in English); f) combine synonyms (Horst & Hout, 2016), e.g., molletta per i fogli, pinzetta per i fogli, (clip in English); g) consider correct names those with elaborations (Cannard et al., 2005), e.g., chiave inglese instead of chiave (wrench in English).

The second measure was the H statistics of the name agreement. The H value considers the number of alternates that have been given by subjects for a target picture. The computation of H did not take into account “do not know name” (DKN) or “do not know object” (DKO) responses (for more information see Snodgrass & Vanderwart, 1980). Besides these two kinds of response, in this study “do not remember the name”, incomplete and unintelligible answers were not considered

Four persons independently coded synonyms names. The percentage of agreement was 95%. Disagreements were solved after discussion with a five judge.

Coding Function agreement

The answers given to the function question were coded to determine the percentage of the function agreement for each object, and for each age group. As for the name agreement, this measure was computed on the total of the right answers and the total of the given ones.

Since the answers differed from those related to the name only in terms of grammatical elements, namely verbs instead of names, a criterion similar to that used to determine the name agreement was adopted. Specifically, a) only right answers were considered, that are those belonging to the Yes category (second coding criterion); b) don't know the function and don't remember answers were not present in right responses; c) misspellings were corrected and considered; d) the first function when multiple ones were typed was only included; e) qualifiers were not considered, e.g., lavare bene i piatti (wash dishes well in English) instead of lavare i piatti (wash dishes in English); f) similar function expressions were combined, e.g., lavare i piatti, pulire i piatti, strofinare i piatti (wash dishes; clean dishes; rub dishes in English); g) also the functions with elaborations were considered correct, e.g., sturare il lavandino instead of sturare (unclog the sink instead of unclog in English).

Four persons independently coded similar function expressions. The percentage of agreement was 95%. Disagreements were solved after discussion with a five judge.

Statistical analysis

As a first step, the analyses regarding the first coding criterion were reported. Explorative analyses on familiarity and frequency of use were conducted to show the distribution of the data by boxplots, and the correlations between the variables by means of Spearman's correlation coefficient. Mann-Whitney rank test was used to evaluate the differences between males and females, using the gender as between subject factor and the familiarity and frequency of use as dependent variables. The age effect on familiarity and frequency of use was analysed by Non Linear Regression analysis (quadratic link function) with the age (years) as covariate and familiarity and frequency of use as dependent variables. The distances between the objects according to the familiarity score, the frequency of personal use score, and frequency of observed use score were evaluated by using Multidimensional Scaling procedure.

As a second step, the analysis on the second coding criterion was illustrated. Four Generalized Linear Model (GLzM, Nelder & Wedderburn, 1972) with normal distribution have been applied. The three levels of object familiarity (high, medium, and low) and the age were between-subject factors. For each model, the dependent variables were respectively the occurrence of responses concerning the four categories of familiarity established by the second coding criterion, i.e., Yes, No, YesAA, NoIA. The factors were the scores in personal and the score in observed frequency of use. This analysis was performed to define the level of awareness of object knowledge and intuition across the three age groups.

Finally, the analysis regarding the H statistic measure of the name agreement was reported. The H value considers the number of alternates that have been given by subjects for a target object. The information statistic, H, was computed for each picture by the formula (following Snodgrass & Vanderwart, 1980):

$$H = \sum_{i=1}^{k} Pi \log 2(1/Pi)$$

where k refers to the number of different names given to each object, and Pi is the proportion of subjects who gave each name.

Statistical analyses were performed using SPSS software.

Results

Coding Familiarity Criterion 1

Descriptive analysis of the whole sample

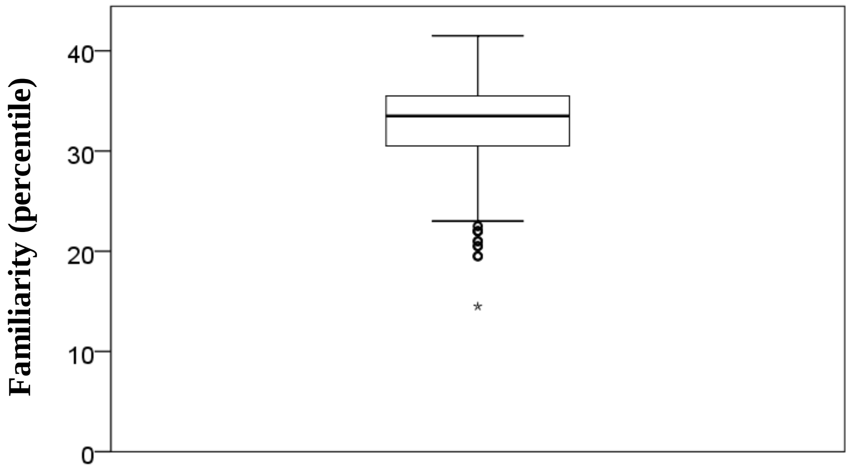
A description of familiarity and frequency of personal use and observed use variables is depicted by box plot graphs (see Figure 1). As the figure shows, the distribution in the whole sample is skewed, and some outliers appear in all the variables.

Spearman correlation (Wayne, D. W., 1990) showed a high correlation between frequency of personal use and frequency of observed use (Rho= .752, $p < .001$), a fairly high correlation between familiarity and frequency of personal use (Rho= .579, $p < .001$), and not high but significant correlation between familiarity and frequency of observed use (Rho= .398, $p < .001$).

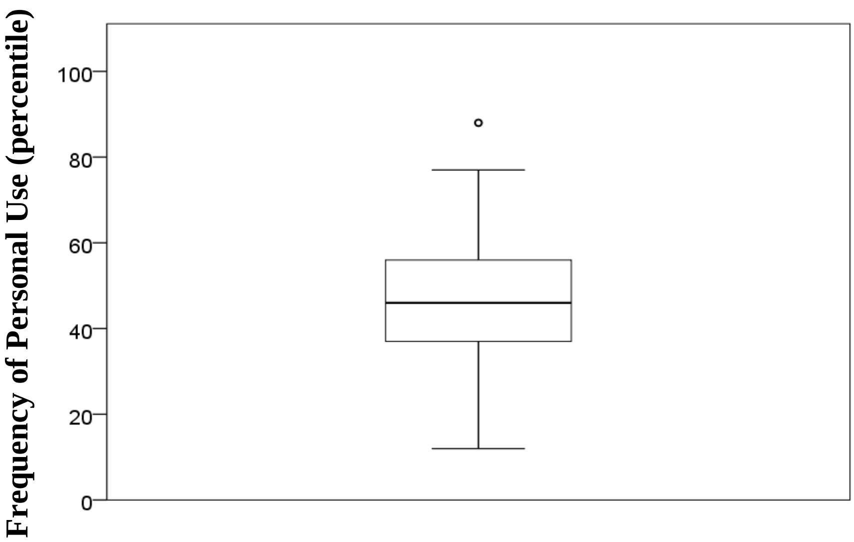
Mann Whitney test (Mann, H. B., Whitney, D. R., 1947) showed differences between males and females considering familiarity (U=1936.5, p=.014) and frequency of personal use (U=2077, p=.045) but not frequency of observed use (U=2634, p=.845). Females showed higher scores than males (see Figure 2).

Figure 1. Simple box plot graphs of Familiarity (A), Frequency of Personal Use (B) and Frequency of Observed Use (C)

A



B



C

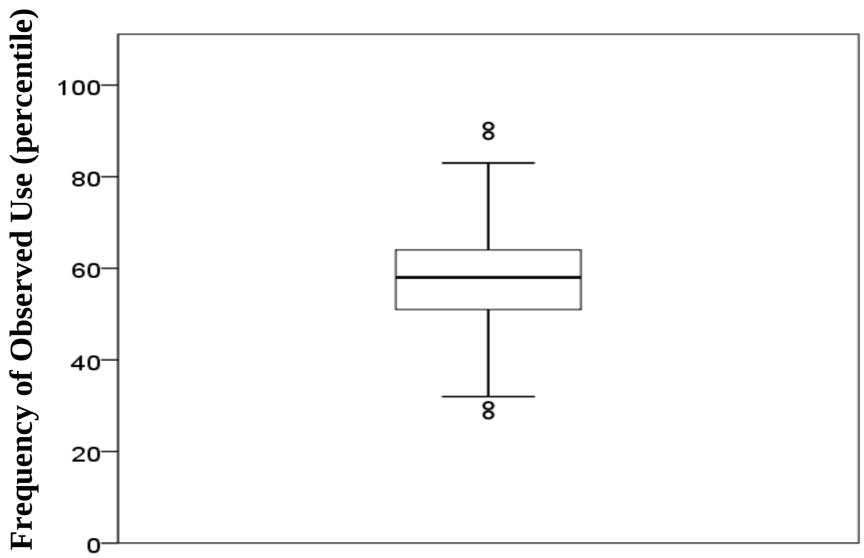
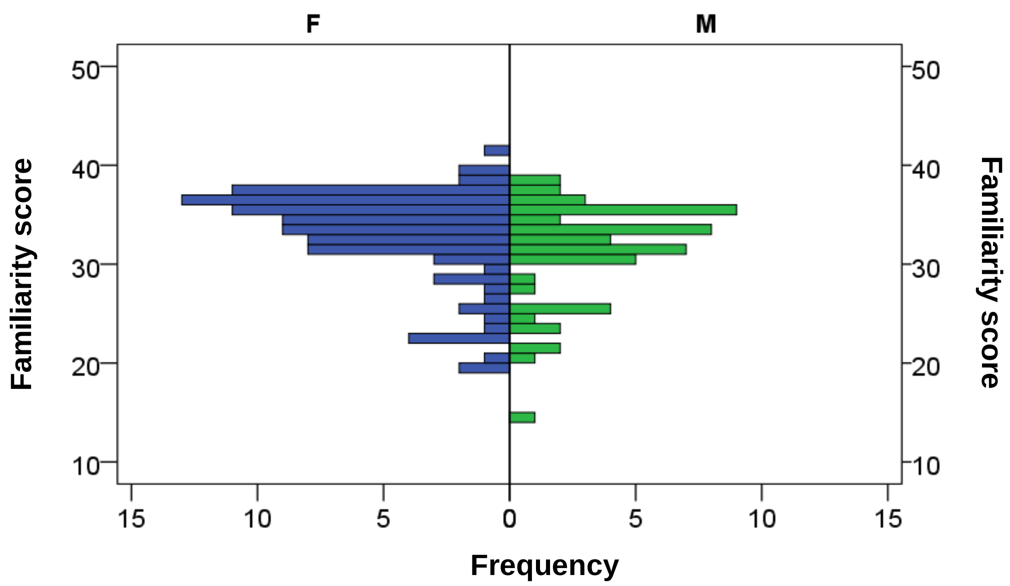
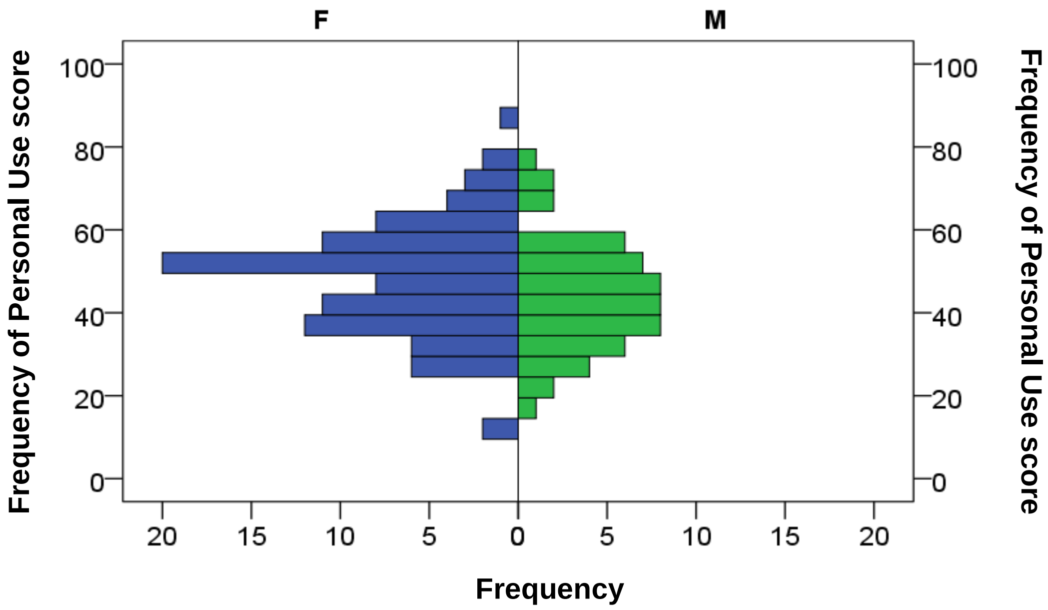


Figure 2. Histogram of Familiarity (A) and Frequency of Personal Use (B) score distribution in males and females.

A



B

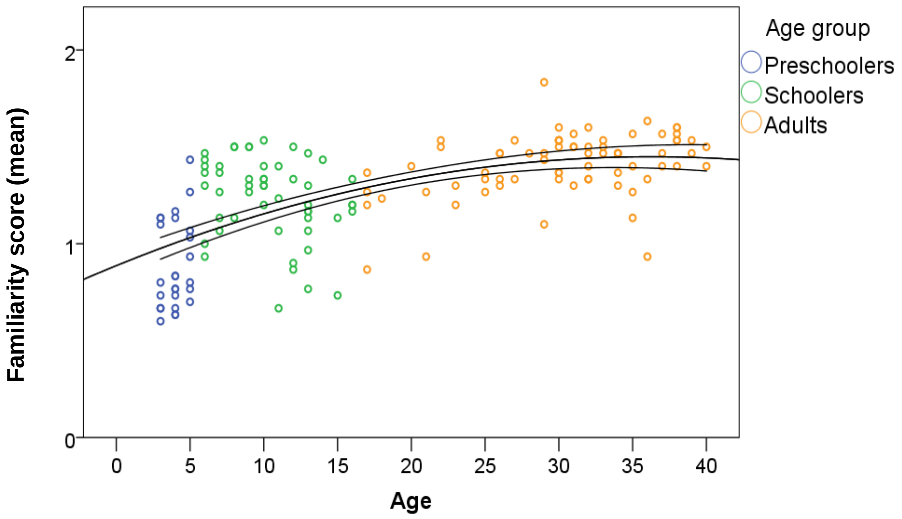


Age effect on familiarity and frequency of use variables

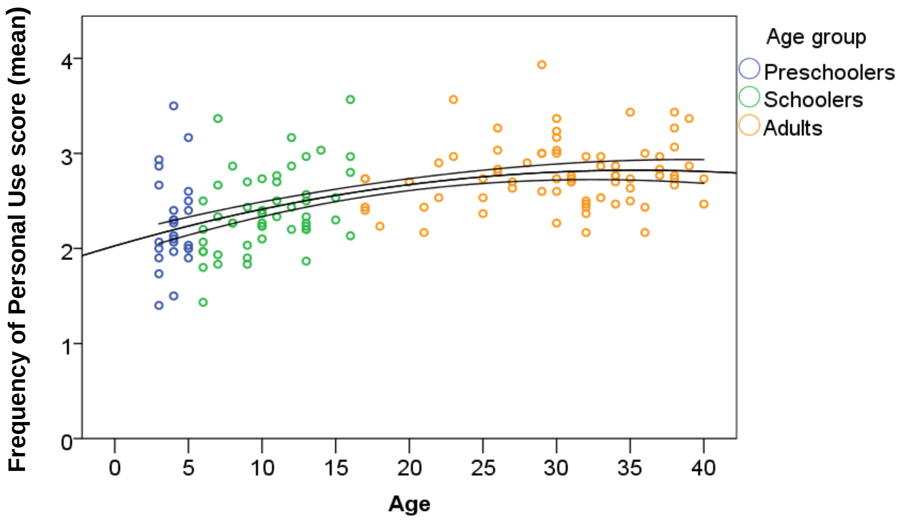
Three Generalized Linear Models (GLzM, Nelder & Wedderburn, 1972) have been applied to test the age effect on the familiarity score and frequency of personal use score and frequency of observed use score (used as dependent variables). In all the models, the age was used as quantitative factor. A quadratic link function was considered because it demonstrates the best fitting function according to Pseudo R Squared index and parsimony criteria (see Table A2 in Appendix A). Figure 3 illustrates the age effect for familiarity, frequency of personal use, and frequency of observed use. As can be seen in the graphs, age affected both familiarity and frequency of use. The major increment was visible for familiarity and frequency of personal use, while high variability emerged in the frequency of observed use (see Table 1).

Figure 3. Scatter graphs of Age affect for Familiarity (A), Frequency of Personal Use (B) and Frequency of Observed Use (C)

A



B



C

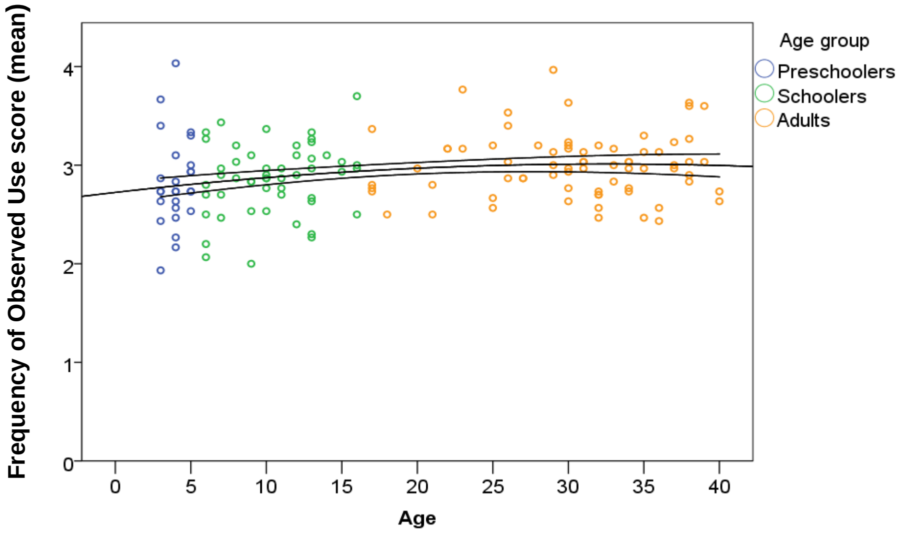


Table 1. Summary Statistics of the age effect on Familiarity, Frequency of use Personal Use and Frequency of Observed Use

Age effect	*B*	Wald's Lower Confidence interval	Wald's Upper Confidence interval	Wald Chi Square	*p*	Exp(B)
Familiarity	.055	.025	.085	12.649	<.001	1.056
Frequency of Personal Use	.159	.061	.257	10.104	<.001	1.172
Frequency of Observed Use	.068	-.040	.176	1.535	.215	1.071

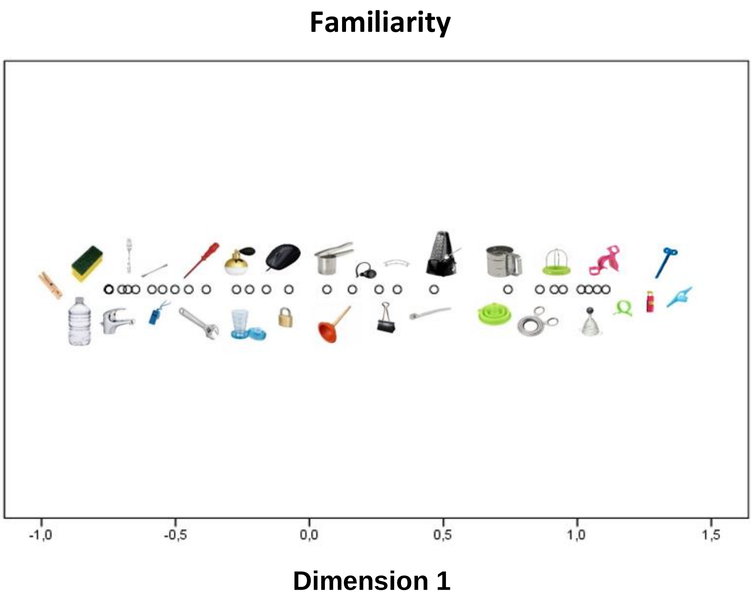
Object classification into three levels of familiarity, frequency of personal use and frequency of observed use: high, medium, low

Three Multidimensional Scaling (MDS; Busing et al., 1997) using the PROXSCAL scaling algorithm were applied to find the distances among the objects according to Familiarity and Frequency of Use indexes evaluated by all the participants. The unidimensional model based on Euclidean distance was selected because only one dimension (familiarity or frequency of personal use or frequency of observed use) was considered as a reference for the distance between the objects. Using this approach, the unidimensional model was the best model to represent the objects along a linear continuum from the minimum to max (or vice versa) of familiarity or frequency of use. As it can be seen in MDS of familiarity for all age groups (Figure 4, A below), the items were distributed from the most familiar (from the left of the linear continuum) to the least familiar (to the right of the linear continuum). The medium level was represented with zero. In particular, at the left end, there was a greater overlapping of the items represented by the most familiar objects in all age groups. In MDS of frequency of personal use (Figure 4, B), the items were distributed in an opposite way from the MDS of familiarity, i.e., from the least familiar (from the left of the linear continuum) to the most familiar (to the right linear continuum). At the left end, there was a greater overlapping of the items represented by the least familiar objects in all age group. This occurred because the variability was higher in less familiar objects. In MDS of frequency of observed use (Figure 4, C), the items were distributed in the same way of the MDS of frequency of personal use, i.e., from the least familiar (from the left of the linear continuum) to the most familiar (to the right of the linear continuum). Also, in this case, at the left end, there was a greater overlapping of the items represented by the least familiar objects in all age groups (more details in Tables A3, A4, and A5 in Appendix A, where all weights on Dimension 1 are specified).

Starting from this analysis, objects were classified into three categories: high, medium, and low in familiarity, frequency of personal use, frequency of observed use, for the three age groups (preschoolers, schoolers, adults). Ten objects were designated for each category. The order of the objects ranged from the most familiar/personally used/seen used by others to the least familiar/personally used/seen used by others, e.g., the clothespin is the most familiar and the thumb book holder the least one (see Tables A3, A4, A5 in Appendix A. They show the three classifications: high, medium, and low in familiarity, frequency of personal use, frequency of observed use).

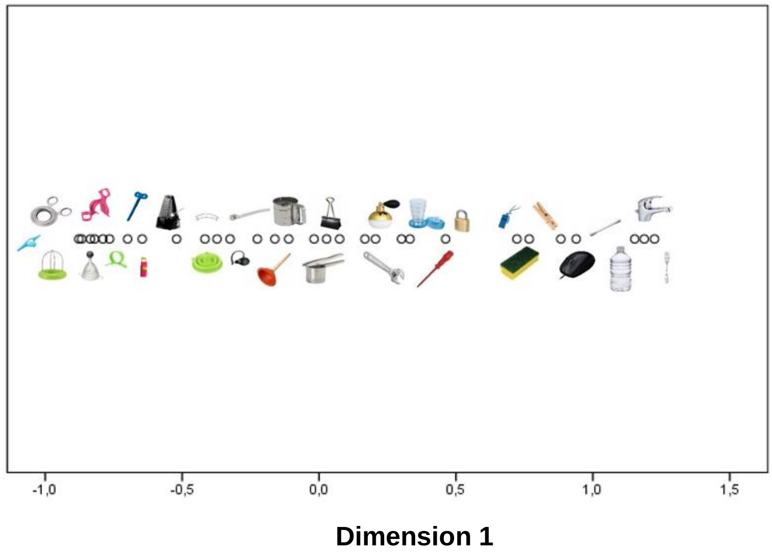
Figure 4. Plotted results of Multidimensional Scaling of Familiarity (A), Frequency of Personal Use (B), Frequency of Observed Use (C) for all age groups. With pictures superimposed based on their weight on Dimension 1.

A



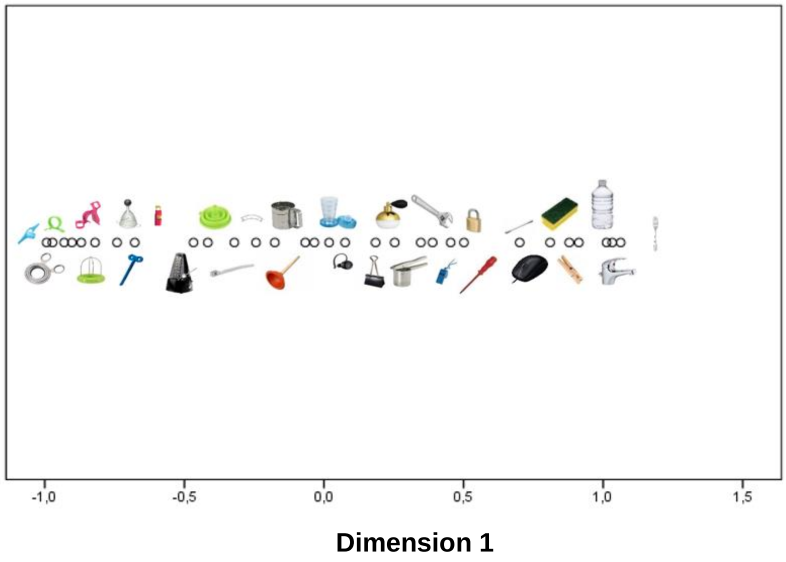
B

Frequency of Personal Use



C

Frequency of Observed Use



Interaction between Familiarity and Frequency of Use variables

A description of the interaction between the three levels of object familiarity and frequency of personal and observed use variables across the three age groups is depicted by six scatter plot graphs (see Figures from A1 to A6 in Appendix A). Comparing objects of high familiarity with the frequency of personal and observed use, adults reached higher scores in both interactions. Thus, they were more familiar with objects because they both personally use them and see them being used by others. Schoolers, and especially preschoolers, were instead more familiar with objects not because they personally use them but because they see them being used by others. As for the interaction between the objects of medium familiarity and the frequency of personal and observed use among the three age groups, adults and schoolers were those that personally use the objects and see them being used by others more frequently. In contrast, preschoolers never or rarely use the objects personally and sometimes see other people using them. The interaction between the objects of low familiarity and the two variables of frequency of use was the most curious. Specifically, the younger group, compared with the older ones, showed a higher frequency of both personal and observed use. This result may be linked to the next analysis (Coding Criterion 2), which investigated the level of awareness of object knowledge since a discrepancy between familiarity and naming and function responses was found.

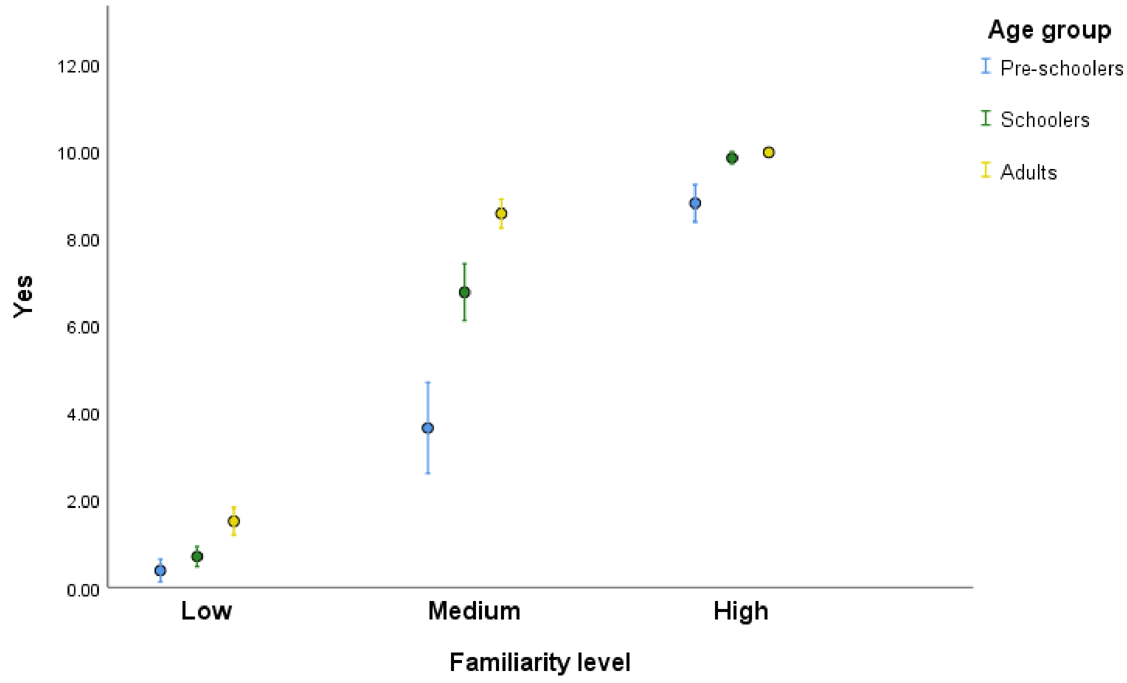
Coding Criterion 2

Four Generalized Linear Model (GLzM, Nelder & Wedderburn, 1972) with normal distribution have been applied. The three levels of object familiarity (high, medium, and low) and the age were between-subject factors. For each model, the dependent variables were respectively, the occurrence of responses concerning the four categories of familiarity established by the second coding criterion, i.e., Yes, No, YesAA, NoIA. The factors were the scores in personal and the score in observed frequency of use.

Overall, the main effect of each individual variable and their interactions were significant. A detailed description of each GLzM is reported below. Graphs of the GLzMs (Figures from 5 to 8 below) and percentage of familiarity, frequency of personal use and observed use responses based on coding Criterion 2, in preschoolers, schoolers, adults (Tables from A6 to A8) are available in Appendix A.

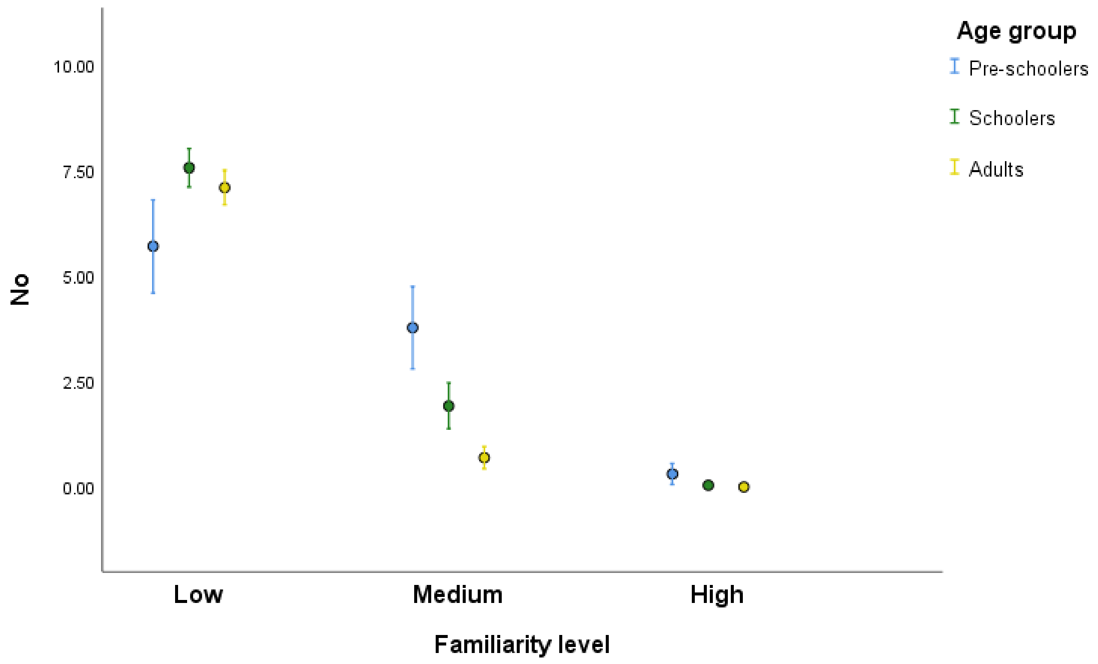
Considering the first category of object familiarity response (i.e. Yes), it correlated with the age groups, the levels of object familiarity and the two types of frequency of use, the main effect of age was significant with Wald Chi-Square= 53.74, df 2, $p < .001$, as was the main effect of the levels of object familiarity, Wald Chi-Square= 230.73, df 2, $p < .001$, the main effect of the frequency of personal use, Wald Chi-Square 8.13, df 1, and $p=.004$, and the main effect of the frequency of observed use, Wald Chi-Square= 7.27, df 1, and $p=.007$. The interaction between the age and the levels of object familiarity was significant with Wald Chi-Square=59.57, df 4, and $p < .001$. Figure 5 illustrates the interaction between the Yes category of familiarity response and the three levels of object familiarity across the three age groups. As the graph shows, the occurrence of Yes responses increases as the level of familiarity of the objects increases. The highest concentration occurs in the adult group.

Figure 5. Graph of Yes category of familiarity correlated with the age groups and the levels of object familiarity



The analysis conducted on the No category of response correlated with the age groups, the levels of object familiarity, and the two types of frequency of use, was also significant. The main effect of object familiarity was significant with Wald Chi-Square= 151.95, df 2, $p < .001$, as was the main effect of the frequency of observed use, Wald Chi-Square= 21.91, df 1, $p <.001$. The main effect of age was not significant, Wald Chi-Square= 2.64, df 2, and $p=.266$, as was the main effect of the frequency of personal use, Wald Chi-Square = 1.89, df 1, and $p=.168$. The interaction between the age and the levels of object familiarity was significant with Wald Chi-Square= 34.92, df 4, and $p < .001$. Figure 6 illustrates the interaction between the No category of familiarity response and the three levels of object familiarity across the three age groups. As the graph shows, overall, the occurrence of No responses decreases as the level of familiarity of the objects increases. The higher concentrations occur in schoolers and adults for objects of low familiarity, and in preschoolers for objects of medium and high familiarity.

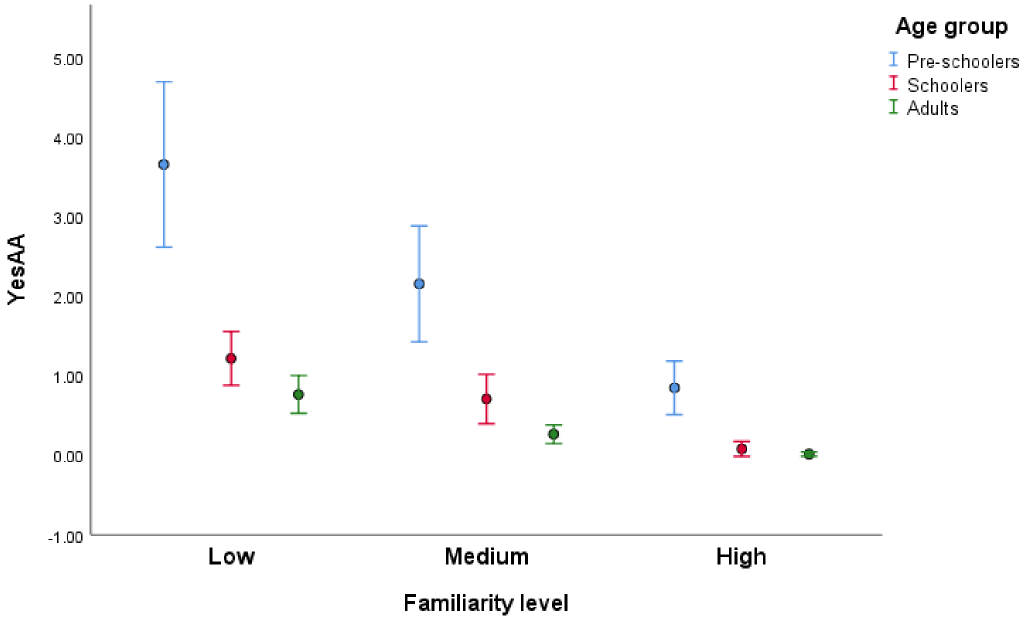
Figure 6. Graph of No category of familiarity correlated with the age groups and the levels of object familiarity



With regard to YesIA category of response, checked with the age groups, the levels of object familiarity, and the two types of frequency of use, the main effect of age was significant with a Wald Chi-Square= 51.16, df 2, $p < .001$, as was the main effect of object familiarity, Wald Chi-Square= 45.36, df 2, $p < .001$, and the main effect of the frequency of observed use, Wald Chi-Square= 9.45, df 1, p= .002. In contrast, the main effect of frequency of personal use was not significant with a Wald Chi-Square= 1.74, df

1, p= .186. The interaction between age and the levels of object familiarity was significant with a Wald Chi-Square= 28.14, df 4, p < .001. Figure 7 explains this interaction: the highest concentration of the alternative answers occurs in preschoolers and decreases as object familiarity increases.

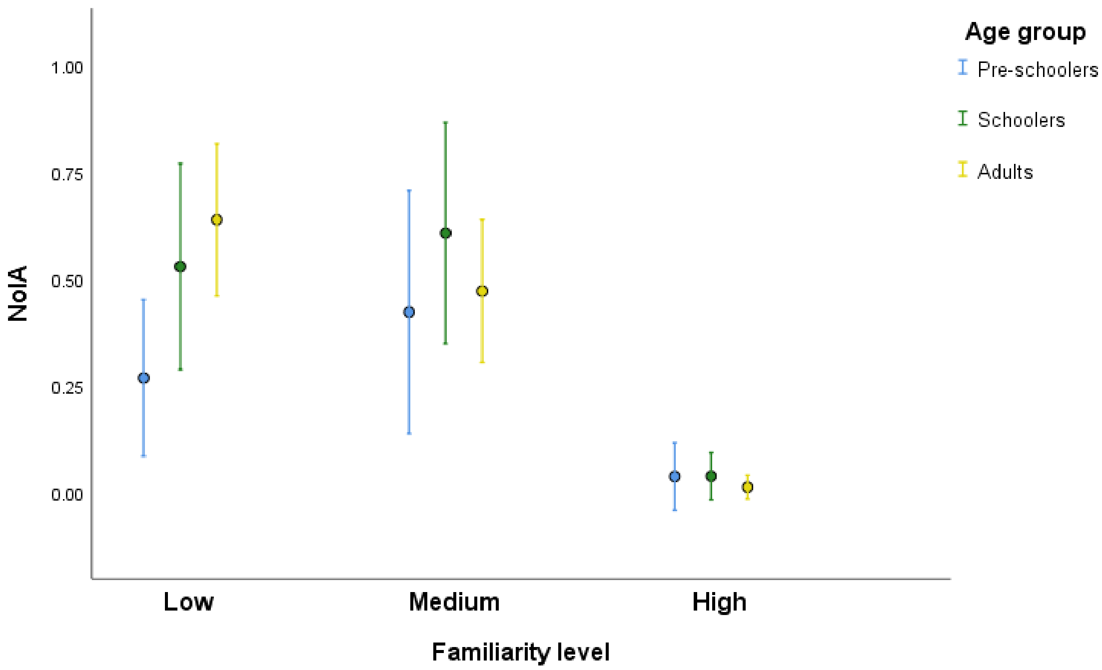
Figure 7. Graph of YesAA category of familiarity correlated with the age groups and the levels of object familiarity



As for the analysis on NoIA category of response, correlated with the age groups, the levels of object familiarity, and the two types of frequency of use, the main effects of age and the levels of object familiarity were significant, while the interaction between these was not. The main effects of the two types of frequency of use were also not significant. Specifically, the main effect of age was significant with a Wald Chi-Square= 7.09, df 2, p= .029, as was the main effect of the levels of object familiarity, Wald Chi-

Square= 11.70, df 2, p= .003. The main effect of the frequency of personal use was not significant, Wald Chi-Square= 1.16, df 1, p= .281, as was the main effect of the frequency of observed use, Wald Chi-Square= 2.33, df 1, p= .127, and the interaction between age and the levels of object familiarity, Wald Chi-Square= 4.68, df 4, p= .321. As the graph in Figure 8 shows, overall, the occurrence of NoIA responses decreases as the familiarity of the objects increases. The higher concentrations occur in adults for objects of low familiarity, in schoolers for objects of medium familiarity, and in preschoolers for objects of high familiarity.

Figure 8. Graph of NoIA category of familiarity correlated with the age groups and the levels of object familiarity



Descriptive overview of Familiarity variable to define the awareness level (high/low) of object knowledge across three age groups

Here the highest value in terms of percentage related to each familiarity category, *Yes*, *No*, *Yes Alternative Answer* (*YesAA)*, *No Intuitive Answer* (*NoIA)*, set for the second coding criterion, were reported. For the first two categories (*Yes* and *No*) Samuelson and Smith's (1999) 85% agreement threshold was used. For the second ones (*YesAA* and *NoIA*), the highest percentages observed were described.

As it can be seen from Table A6 in Appendix A, three objects in the first group (pre-schoolers), fours objects in the second one (schoolers), and ten in the last group (adults) reached 100% percentage of *Yes* responses. The common ones were three: 'clothespin', 'fork', 'sponge'. This revealed that, overall, these objects are the most familiar ones; then that all age groups, for these, manifested the highest awareness level of knowledge about familiarity. Other three objects in the first group, eight in the second one, and six in the last group exceeded the consent threshold by Samuelson and Smith.

No object reached 100% consent in *No* responses, but one percentage (98% for 'thumb book holder' in the schoolers' group) was very close. Then, two objects in the first group, four in the second one, and two in the last group reached and exceeded the set-out agreement threshold. Generally, the percentage of *No* responses in less familiar objects was higher in schoolers and adults than in pre-schoolers, demonstrating a higher level of awareness about object familiarity in older participants.

Regarding percentage of *YesAA* responses, the highest one (77%) was related to the tube squeezer in the pre-schoolers' group. In general, the percentage was higher in the preschoolers' group, outlining a higher level of creativity in younger participants.

Percentages in *NoIA* responses were usually low. These responses were more frequent in the adults' group, revealing a higher level of intuition in older participants than younger ones. The highest percentages (23%; 22%; 19%) were referred at the egg scissors in all age groups. This object was categorized as an unfamiliar object, but its structural features are so obvious that easily help to guess the function.

Qualitative outline upon the percentages relating to the Use and Frequency of Use responses

As it can be seen from Table A7 in Appendix A, regarding Frequency of Personal Use variable, the objects that generally reached the agreement threshold of 85% were few. Considering the two opposite point rating scales, *never* and *very often*, the least used object in all three groups was the 'thumb book holder', a non-familiar object. The most used one, common to all groups, was the 'fork', one of the most familiar objects.

As Table A8 in Appendix A shows, regarding Frequency of Observed Use, the least personally used object ('thumb book holder') was also the least seen object used by others. Similarly, the most personally used object ('fork') was also the most seen object used by others.

Comparing Familiarity scores with Frequency of Personal Use and Observed Use ones, generally unfamiliar objects were those less personally used and seen used by others confirming the low level of their knowledge. Curiously, objects such as sponge, screwdriver, padlock, considered as more familiar, resulted less personally used, but most seen used by others, especially in pre-schoolers' group.

Normative scores

The assignment of the score between 0-1,5 to the four qualitative categories of responses in Familiarity task was used to create normative scores. As seen above, in the age groups distribution some outliers were found, and these were removed from the sample. Tables 2 and 3 show descriptive statistics of Familiarity and Frequency of Use for each age groups, males and females.

Table 2. Normative scores of Familiarity for pre-schoolers (on the left), schoolers (in the middle), adults (on the right)

		Statistics[a] Familiarity					
		Pre-schoolers		**Schoolers**		**Adults**	
		F	**M**	**F**	**M**	**F**	**M**
N.		11	15	23	24	56	15
Mean		24.77	24.96	32.36	32.91	35.32	34.76
Std. Deviation		4.50	4.81	2.57	2.05	2.37	2.45
Percentiles	**5**	19.50	14.50	27.20	28.50	30.85	30.00
	25	20.50	21.00	31.00	31.50	34.00	33.00
	50	24.50	25.50	32.00	33.00	35.50	35.00
	75	30.00	30.00	34.50	35.00	37.00	36.50

Table 3. Normative scores of Frequency of Personal Use and Observed Use for pre-schoolers (on the left), schoolers (in the middle), adults (on the right)

		Statistics[a] Frequency of Personal Use						Statistics[a] Frequency of Observed Use					
		Pre-schoolers		Schoolers		Adults		Pre-schoolers		Schoolers		Adults	
		F	M	F	M	F	M	F	M	F	M	F	M
N.		9	15	25	24	55	14	9	15	27	22	55	14
Mean		33.66	39.40	41.08	42.37	53.47	47.57	52.11	55.66	54.59	59.18	59.36	57.35
Std. Deviation		5.85	14.06	9.99	12.38	9.26	5.31	5.64	12.90	11.13	7.77	8.88	6.77
Percentiles	**5**	27.00	15.00	25.00	24.50	35.00	41.00	44.00	35.00	32.40	42.45	44.00	45.00
	25	29.50	31.00	34.50	34.50	48.00	42.75	48.00	46.00	46.00	55.75	53.00	51.75
	50	30.00	38.00	40.00	40.00	52.00	47.00	52.00	55.00	54.00	58.50	59.00	58.00
	75	40.50	50.00	48.50	51.75	60.00	53.00	55.00	69.00	63.00	66.00	65.00	61.00

Name and function agreement

For each object, the percentage of preschoolers, schoolers, and adults using the expected name and function was computed. The percentage was calculated: a) on the total of the right responses for each age group; b) on the total of the responses for each age group; c) on the total number of responses given by the whole sample.

In addition, the H statistic measure of the name agreement was calculated. The H value considers the number of alternates that have been given by subjects for a target picture. The information statistic, H, was computed for each object by the formula (following Snodgrass & Vanderwart, 1980):

$$H = \sum_{i=1}^{k} P_i \log_2(1/P_i)$$

where k refers to the number of different names given to each object, and Pi is the proportion of subjects who gave each name.

For the percentage measure, a higher number signifies greater name agreement. However, for the H measure, a lower number signifies greater name agreement; for example, when all subjects supply the same name, the value is 0. A higher value indicates that a greater number of alternative names was supplied.

Name agreement

Considering preschoolers, three objects out of the ten more familiar ones reached 100% of name agreement on the total of the responses of the age group. In contrast, eight objects out of the ten less familiar reached 0% of name agreement since no answer was provided. Curiously, this group produced two modal names with the same percentage (50%) for two objects (i.e., for the binder clip and the tap) on the total of the right answers. Schoolers agreed 100% with the name agreement for two out of the ten more familiar objects on the total of the responses of the age group for, and 0% for seven out of the ten less familiar objects. Finally, adults provided 100% of name agreement on the total of the responses of the age group for six out of the ten more familiar objects. The highest percentage of name agreement among less familiar objects was 60% (i.e., folding funnel), which is significantly below the 85% agreement threshold established by Samuelson and Smith (1999). Considering the percentage of name agreement on the total responses given by the whole sample (3-40 years old), the highest percentage among less familiar objects dropped to 45%. This rate confirmed the non-familiarity of objects.

Table 2 presents the degree of name agreement expressed by the information statistic H. It includes values for the whole sample, each age group (preschoolers, schoolers, adults) and each level of object familiarity (high, medium, low).

The information statistic H of each level of object familiarity was highest for preschoolers, demonstrating that the youngest participants produced more alternative names than the subjects in the other two groups. The highest value for the information statistic H of object of high familiarity in preschoolers was 0.28 compared to 0.15 and 0.09 for schoolers and adults, respectively. The highest value for the information statistic H of object of medium familiarity in preschoolers was 1.55 compared to 0.79 and 0.37 for schoolers and adults. The highest value for the information statistic H of object of low familiarity in the youngest group was 3.20 compared to 2.87 and 3.10 for the other two older groups, respectively.

Interestingly, two objects of high familiarity had an H value of 0 in all age groups, i.e., the sponge and the clothespin, which meant that all the subjects provided the same name. The H value of several non-familiar objects (e.g., thumb book holder, tube squeezer) was uncountable in preschoolers and schoolers, because no participant provided the correct name.

The percentages of name agreement and the information statistic H for each object are available in Tables A9 and A10 in Appendix A.

Table 2. Summary of the information statistic H for each age group (preschoolers, schoolers, adults) and each level of object familiarity (high, medium, low)

	Name agreement H all objects			
	Total sample	Preschoolers	Schoolers	Adults
Mean	1,50	1,20	0,87	1,19
SD	2,06	1,17	1,28	1,72
N	149	26	51	72
	Name agreement H objects with high familiarity			
	Total sample	Preschoolers	Schoolers	Adults
Mean	0,15	0,28	0,15	0,09
SD	0,20	0,39	0,18	0,21
N	149	26	51	72
	Name agreement H objects with medium familiarity			
	Total sample	Preschoolers	Schoolers	Adults
Mean	0,47	1,55	0,79	0,37
SD	0,30	0,87	0,96	0,45
N	149	26	51	72
	Name agreement H objects with low familiarity			
	Total sample	Preschoolers	Schoolers	Adults
Mean	3,88	3,20	2,87	3,10
SD	2,01	0,18	1,46	1,77
N	149	26	51	72

Modal function agreement

Preschoolers provided 100% of function agreement on the total of the age group's responses for only one object out of the ten more familiar (i.e., the fork is used to eat). They did not reach a modal function agreement for seven objects out of the ten less familiar since no answer was produced. Interestingly, this group agreed on modal functions that differ from those provided by schoolers and adults for three more familiar objects (i.e., tap, bottle, wrench) and one object of medium familiarity (i.e., mouse). Schoolers agreed 100% for one object out of the ten more familiars (i.e., the sponge is used to wash dishes). 0% of modal function agreement was reached for seven objects out of the ten less familiar. Adults did not reach 100% agreement on objects' function. The highest percentage of agreement was 99%, while the highest percentage of function agreement among less familiar objects was 57% (i.e., sieve). Insofar threshold on function agreement was not set. Here, the threshold set by Samuelson and Smith (85%) was adopted, since the criteria chosen to codify function responses and compute the percentage agreement were similar to that used for the name agreement. Therefore, the highest percentage of function agreement (57%) for less familiar objects found in adults was significantly below the threshold. Considering the percentage of function agreement on the total responses given by the whole sample (3-40 years old), the highest percentage among less familiar objects dropped to 43%. This rate also confirmed the non-familiarity of objects.

The percentages of function agreement for each object are available in Table A11, while synonyms and similar functions were reported in Tables A12 and A13 in Appendix A.

General discussion

In the present study, the first database of familiar and non-familiar everyday objects was proposed. The objects belong to several categories, are characterized by different structural properties and actions referred to their functional use, and are classified according to their age of acquisition, use, frequency of use, name, and function agreement. The database can be useful for research adopting a developmental perspective in cognitive psychology, cognitive science, psycholinguistics, and neuroscience.

As predicted, results demonstrated that age has a crucial impact on objects' familiarity and frequency of use. In particular, the analysis performed on the whole sample showed that as age increases, the level of familiarity and frequency of personal use also increases, reaching stability during adulthood when humans have accumulated more experience from the surrounding environment. Findings also suggested that females fared better with objects' familiarity and frequency of personal use than males. No differences were found between males and females in the frequency of observed use. These results did not align well with those of two studies on the role of gender in naming objects (Capitani et al. 1999; Laws, 1999), showing that females did better with fruits and males with tools' names and that females were slower than males to name non-living things while males were slower to name living things. Considering that in this study all objects are non-living things, these results could be interpreted as opposites. However, the difference might also be due to the fact that many of our objects were kitchen utensils. Further research is necessary to investigate these interesting aspects more in-depth.

The most innovative finding of this contribution is the classification of objects into three categories, high, medium, and low in familiarity, frequency of personal use, and frequency of observed use for three different developmental stages, i.e., preschoolers, schoolers (children and adolescents), and adults. To the best of our knowledge, no database so far has proposed a classification like this. This classification can allow researchers who will decide to refer to this database for the choice of the stimuli to clearly recognize which objects are known and which not in the age group of interest, choosing the appropriate ones.

Another novelty of this work consists of testing not only the responses but the level of awareness of participants. Namely, the interest was to determine to what extent participants were aware that their responses deviated from the standard way in which the objects were named and used. A double coding criterion was used to achieve information on this, adopting a more analytical and more qualitative coding criterion (Coding Criteria 1 and 2). The analysis related to the latter was performed to improve response reliability across the age groups and investigate the level of awareness of participants in their familiarity judgments. As expected, results revealed a higher level of awareness in older participants and a lower one in younger children, confirmed by the frequent use of alternative answers in naming and function questions by the first age group. The fact that children deviated more from standard names and uses can also be seen as a signal of augmented creativity and lower influence by functional fixedness. These results are then in line with those by Cannard et al. (2005): the authors assessed picture naming agreement in young French children demonstrating a greater use of alternative names and a lower naming agreement in 3-4 years old children than in 6-8-year-olds. Moreover, other results associated with this coding revealed a higher level of intuition in finding the correct function of objects of medium and low familiarity in adulthood than in younger groups. Since intuition is generally associated with the implicit information that a person acquires by learning from experience (Plessner et al., 2011), this explains the importance of the wealth of experience in adults during affordance perception. In this respect, interesting information on experience is also given by the way knowledge is acquired and how many times someone is concerned with this knowledge. Results comparing familiarity with the frequency of personal use and use seen by others showed that non-familiar objects were generally less personally used and more often observed when used by others. Curiously, more familiar objects were not always known because these were personally used, but often because they were seen to be used by others. This assigns great value to the influence of other people's action on the perceived familiarity of objects.

Finally, objects are arranged according to their name and function agreement. Object's name agreement is an aspect commonly measured within the several databases existing in the literature. In contrast, to the best of our knowledge, norms on function agreement have never been collected. Considering more familiar objects, these results showed that younger participants, compared to the older ones, provide alternative modal names, and produce different modal functions for some objects. These findings are in line with those by Cycowicz and colleagues (1997), in which the same effect in object name agreement was found, and with the results of the study on object manipulation (see Chapters 6) in which children, compared to preadolescents and adults, interacted with objects not only in the way they are commonly used but also in an alternative and creative manner, thus identifying novel object functions. As to non-familiar objects, the low percentage of their modal name and function agreement confirmed their low familiarity. This finding corresponds to that found by the authors of the NOUN Database (Horst & Hout, 2016).

Overall, this study shows that the age of an individual modulates affordance perception and object knowledge. In particular, the judgment of familiarity of non-familiar objects changes from childhood to adulthood: while children rely mainly on other people's action and/or their creativity and intuitions, adults refer to previous experiences with objects endowed with similar affordances. This database provides a useful instrument for researchers who intend to include familiar and non-familiar objects and their variations in naming and functional familiarity across ages and gender in their studies. The study offers some critical insights into the literature on affordances, motor resonance, and functional fixedness. Children learn mostly by observing others using objects, and their responses are more variable and converge less on a single name/function than those of adolescents and adults. Further research should investigate whether and to what extent this depends on their higher creativity, on their less rich world experience, or a combination of both.

Compared with existing databases, the number of stimuli in the present database might appear low. However, no study so far has proposed a classification of familiar and non-familiar stimuli according to familiarity, frequency of use variables, and function agreement adopting a developmental perspective. Besides, how long attention lasts in small children was previously tested, and 30 turned out to be the optimal number. Thus, this first set of stimuli can represent a valuable resource for studies on objects, particularly for studies with participants of different ages (from childhood to adulthood) in cognitive psychology, neuroscience, psycholinguistics as well as clinical psychology and linguistics.

CHAPTER 4

STUDY 2: CROSS CULTURAL CORRELATION AMONG ITALIAN, DUTCH AND CROATIAN POPULATIONS ON THE FANS DATABASE

Introduction

Factors such as age, sociocultural, anthropological, and linguistic dynamics may affect the perception of objects. For instance, an object that is common in one population may be unusual in others (Sirois et al., 2006; Cuetos et al., 1999; Sanfeliu & Fernandez, 1996); similarly, an object that is familiar for an adult may be unknown for a child. For this reason, particular attention to stimuli selection is crucial for researchers.

Normative studies represent a relevant support for investigators who need of stimuli standardized for different psycholinguistic variables and adapted to various cultural and linguistic situations. Over the years, many norms related to variables such us object picture naming, familiarity, manipulability, age of acquisition (Snodgrass and Vanderwart, 1980; Berman, Friedman, Hamberger, Snodgrass, 1989; Cycowicz et al., 1997; Rossion and Pourtois, 2004; Viggiano et al., 2004; Adlington et al., 2008; Brodeur et al., 2010; 2014; Duñabeitia et al., 2018) and revised in various populations (Alario & Ferrand, 1999; Pompeia et al., 2003; Kremin et al. 2003; Miranda et al., 2004; Yoon et al, 2004; Sirois et al., 2006) have been collected. To our knowledge, standardizations for different languages were especially done for databases of familiar stimuli. The first database, in black and white line drawings, was published by Snodgrass and Vanderwart (1980), then expanded by Cycowicz et al. (1997), in American English language. The two versions, or part of the items of both, were then normalised for French (Alario & Ferrand, 1999; Kremin et al., 2003; Cannard et al., 2005), Brazilian (Miranda et al. 2004), Chinese (Yoon et al., 2004), Spanish (Sanfeliu & Fernandez, 1996), Dutch, English, German, Italian, Russian, Swedish (PEDOI, Kremin et al., 2003) Canadian French (Sirois et al., 2006), Icelandic (Pind et al., 2000). Later, Viggiano and colleagues (2004) presented the first colour photos database tested on two adults' samples, one of English and the other of Italian speakers. Recently, Duñabeitia and collaborators (2018) created a set of coloured pictures of common concrete concepts normed in six different European languages (British English, Spanish, French, Dutch, Italian and German).

As far as we know, normative data for various populations of database of non-familiar stimuli are very few. In 2016, a collection of unfamiliar images, the NOUN Database by Horst and Hout, only standardized for adults, English speakers, was published.

In latest years, research making use of novel and non-familiar stimuli has proliferated. These are generally employed in psycholinguistic tasks, such as object recognition (Smith, 2003; Hummel, 2000), concept categorization (e.g., Homa et al., 2011; Bornstein & Mash, 2010; Smith & Minda, 2002), word learning (e.g., Horst & Samuelson, 2008; Yu & Smith, 2007) or object manipulation, and addressed to participants of different ages (see Study 3 in Chapter 5). Given the strong interest in considering the variable of novelty in many studies, in addition to the availability of very little material about collection of novel stimuli and related normative data for different languages and ages, here norms of Dutch and Croatian populations for the Familiar And Novel Stimuli (FANS) Database are presented. This data might be useful for future research with native speakers of these populations.

In strictly following FANS Database's procedure, norms for familiarity, naming, function, using and frequency of use for Dutch and Croatian populations were collected. The images of the objects were presented and, for each of these, Dutch and Croatian participants were asked whether they knew them, which was their name, which was their function, whether they have used them or seen somebody using them, and with which frequency.

As with the Italian version of the FANS Database, the classification of objects into three levels (high, medium, low) of familiarity and frequency of personal and observed use, for Dutch and Croatian populations, is reported. In addition, a cross cultural analysis among Italian, Dutch and Croatian populations data is discussed.

In conclusion, this study provides researchers with cross cultural norms for familiar and non-familiar objects, useful with participants of different ages whose first language are Italian, Dutch, and Croatian. Importantly, these findings complement those Italian of the Familiar And Non-Familiar Stimuli (FANS) Database in terms of norms for familiarity, frequency of use, of Dutch and Croatian populations, of different age groups, from childhood to adulthood.

Method

Participants

Dutch sample consisted of 104 participants (77 females, 15 left-handed), 31 pre-schoolers (from 3 to 5 years old, 16 females, 4 left-handed) and 73 adults (from 19 to 24 years old, 61 females, 11 left-handed). Children were recruited through a database of the Baby & Child Research Center (Radboud University, Nijmegen). Parents provided written consent for their child's enrolment in the study. Children were compensated with a sticker book. The adults were students of the Radboud University, in Nijmegen. Before starting, they gave written consent. They received course credit for their participation.

The study was carried out according to the standard guides and regulations approved by the ethics committee at Radboud University.

A total of 152 Croatian speakers (103 females, 10 left-handed) took part into the study and were divided as follows: pre-schoolers, 7 participants (from 3 to 5 years old, 3 females, no left-handed); schoolers, 43 participants (from 6 to 16 years old, 20 females, 6 left-handed); adults, 102 participants (from 17 to 40 years old, 80 females, 4 left-handed). Children were recruited online by contacting their parents via email and social network; adults were students of the University of Zagreb and parents of the children participants. Before taking part into the study, adults and parents for children signed informed consent forms.

Dutch and Croatian children, as the Italian ones, needed of parental participation in order to assure the reading and the comprehension of the task but not the help in answering.

Materials

The stimuli were the same of the Familiar And Non-Familiar Stimuli (FANS) Database (see Chapter 3). These included thirty images of familiar and non-familiar objects of daily use, belonging to six different categories (e.g., tools, objects for personal care, office supplies), and characterized by different structural features, i.e., the shape, the texture and the size, and functional properties, i.e., the information related to grasp and the use of an object. The objects were coloured 3D images with white background and the size of the images was of 180 pixels in width and in height.

Procedure

The procedure was identical to that applied for the FANS Database in order to obtain the same information from Dutch and Croatian samples. Specifically, participants were asked to take part in an online questionnaire lasting approximately 30 minutes. Each participant saw thirty images of daily use objects, one at a time, and was asked to answer five written questions, namely:

1- Do you know this object? Yes/No

2- If yes, what is it? / If no, what it could be?

3- If yes, what is it for? / If no, what could it be for?

4- Did you use it yourself or did you see someone use it?

5- How often? Never/Rarely/Sometimes/Often/Very often.

During the presentation of each of the five questions, the image of the object was always presented. Once the five responses for each object were typed, the image of the following object and its questions were displayed. During the questionnaire, the 30 objects images were presented in random order. Participants were allowed to return to the previous questions in order to change or complete the responses. All the responses were mandatory. Questions were presented in a way easy to understand by younger children. Indeed, in the instructions, concepts such as familiarity and frequency of use, which 3-year-olds have not yet acquired, were did not used. Moreover, parental participation for children from 3 to 10 years old assured their comprehension. Parents of children from 3 to 10 years old had specific instructions: they had to read the questions, assure the child's comprehension, avoid any help or suggested answers, and type precisely what they said.

Analysis

Coding Familiarity

The Dutch and Croatian responses related to the familiarity questions (the first three ones: 1- Do you know this object? Yes/No; 2- If yes, what is it? / If no, what it could be?; 3- If yes, what's it for? / If no, what could it be for?) were coded using the criterion adopted for the FANS Database in order to direct compare these data with those of Italian participants. The criterion assigns a quantitative score between 0-2, where 0 indicate that participants gave wrong answers both to the second and to the third questions, and 2 that participants gave a right answer to both questions.

As for the Italian data, the coding was checked by two persons for each population. The percentage of agreement for Dutch data was of 94%, while for Croatian ones of 95%. Disagreements were solved after discussion.

Statistical analysis

As a first step, the distances between the objects according to the familiarity score, the frequency of personal use score, and frequency of observed use score by using Multidimensional Scaling procedure were analysed.

As a second step, the correlation between the familiarity and the frequency of use variables across Italian, Dutch, and Croatian samples and the three age groups (preschoolers, schoolers, adults) was performed through a Generalized Linear Model

(GLzM, Nelder & Wedderburn, 1972) with Normal distribution and Power-log link function. The three nationalities were between factors. Familiarity was the dependent variable. Age, frequency of personal use and frequency of observed use are covariate variables. Statistical analyses were performed using SPSS software.

Results

How familiarity and frequency of use of thirty everyday objects differ among Dutch, Croatian and Italian pre-schoolers, schoolers, and adults was investigated. First, the classification of objects into three levels of familiarity, frequency of personal use, and frequency of observed use (high, medium, and low for Dutch and Croatian samples) is reported. Then, the results of the analysis of familiarity and frequency of use variables across the three samples and the different age groups are described.

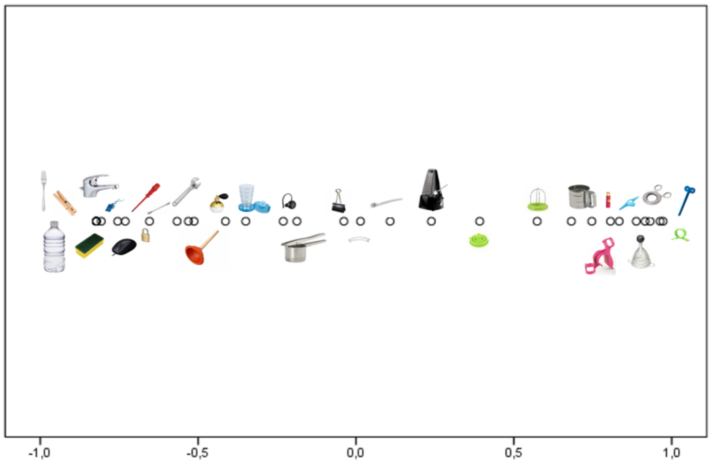
Object classification into three levels of familiarity, frequency of personal use and frequency of observed use: high, medium, low

Six Multidimensional Scaling (MDS; Busing et al., 1997) using the PROXSCAL scaling algorithm were applied to find the distances among the objects according to Familiarity and Frequency of Use indexes evaluated by all Dutch and Croatian participants, separately. The unidimensional model based on Euclidean distance was selected because only one dimension (familiarity or frequency of personal use or frequency of observed use) was considered as a reference for the distance between the objects. Using this approach, the unidimensional model was the best model to represent the objects along a linear continuum from the minimum to max (or vice versa) of familiarity or frequency of use. As it can be seen in MDS of familiarity for all Dutch and Croatian age groups (Figure 1 and 2, top panel), the items were distributed from the most familiar (from the left of the linear continuum) to the least familiar (to the right of the linear continuum). In particular, at the left end, there was a greater overlapping of the items represented by the most familiar objects in all age groups. In MDS of frequency of personal use (Figure 2, middle panel), the items were distributed in an opposite way from the MDS of familiarity, i.e., from the least familiar (from the left of the linear continuum) to the most familiar (to the right linear continuum). At the left end, there was a greater overlapping of the items represented by the least familiar objects in all age group. This occurred because the variability is higher in less familiar objects. In MDS of frequency of observed use (Figure 2, bottom panel), the items were distributed in the same way of the MDS of frequency of personal use, i.e., from the least familiar (from the left of the linear continuum) to the most familiar (to the right of the linear continuum). Also, in this case, at the left end, there was a greater overlapping of the items represented by the least familiar objects in all age groups (more details in Tables 3, 4, and 5 in Appendix B).

Starting from this analysis, objects were classified into three categories: high, medium, and low in familiarity, frequency of personal use, frequency of observed use, for the three age groups (preschoolers, schoolers, adults; only preschoolers and adults for Dutch). Ten objects for each category were designated. The order of the objects ranges from the most familiar/personally used/seen used by others to the least familiar/personally used/seen used by others.

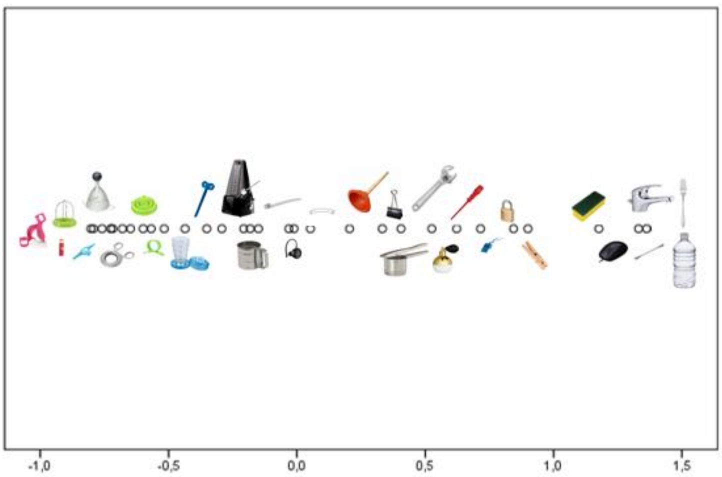
Figure 1. Plotted results of MDS of Dutch familiarity, frequency of personal use and frequency of observed use for all age groups.

Familiarity



Dimension 1

Frequency of Personal Use



Dimension 1

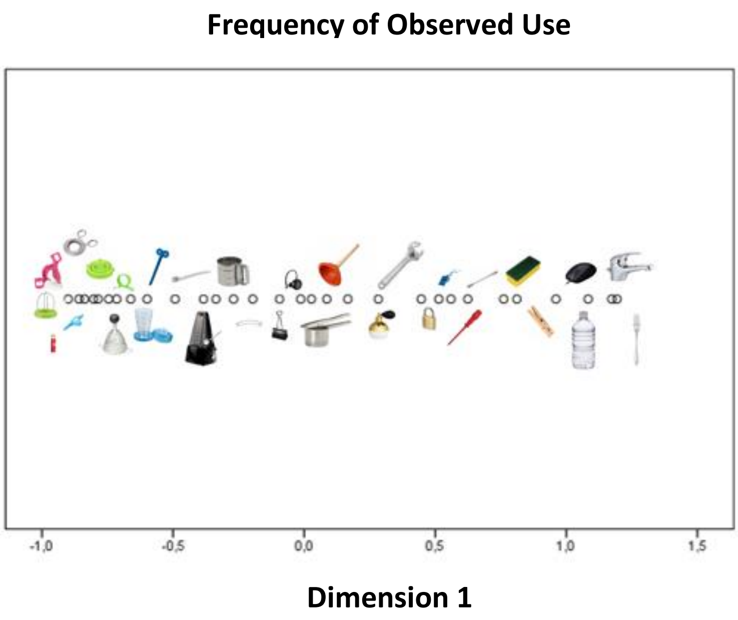
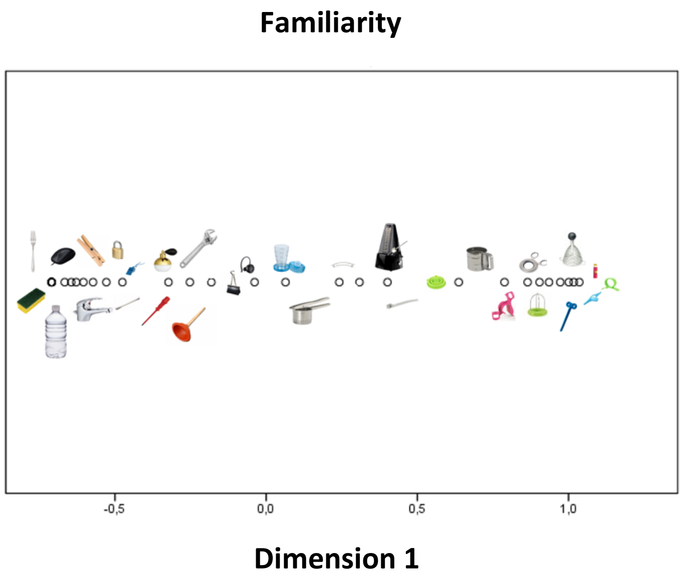
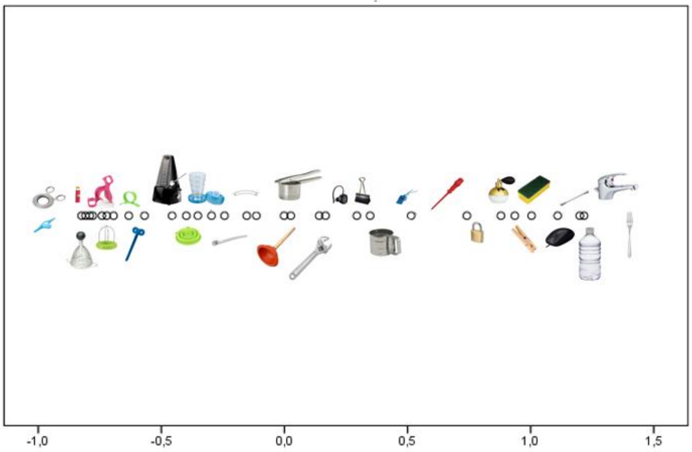


Figure 2. Plotted results of MDS of Croatian familiarity, frequency of personal use and frequency of observed use for all age groups.

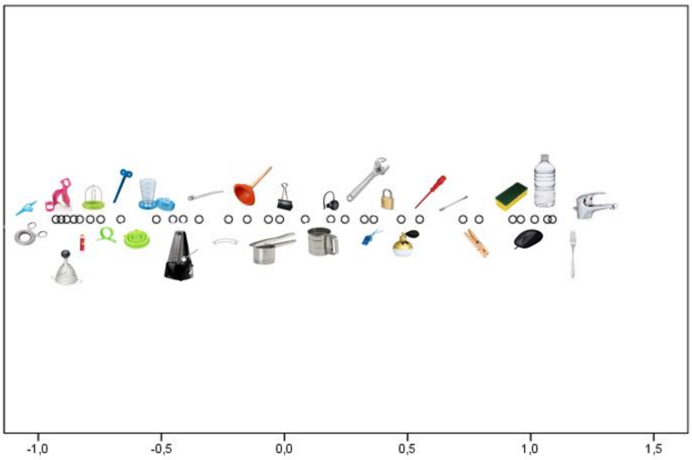


Frequency of Personal Use



Dimension 1

Frequency of Observed Use



Dimension 1

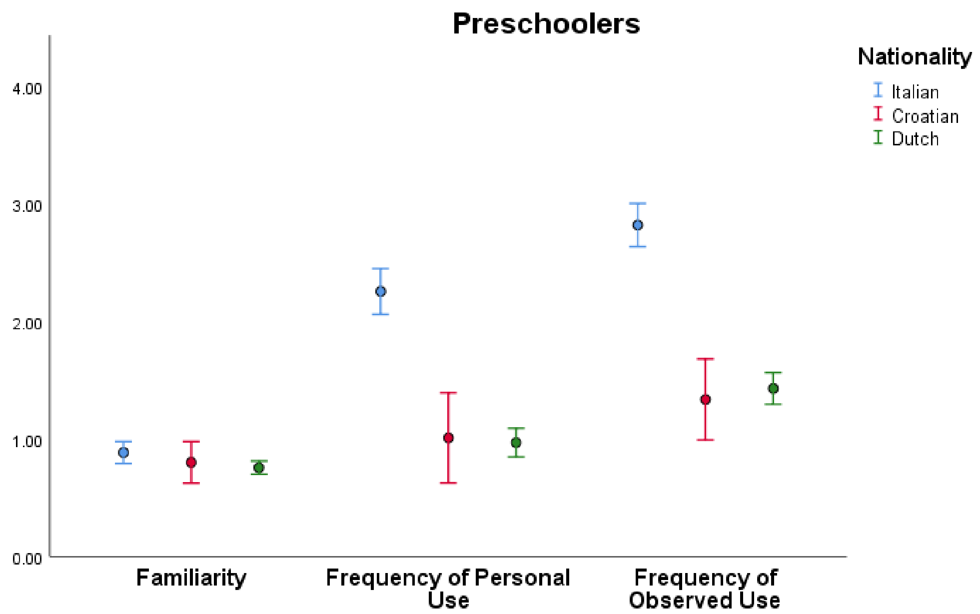
Analysis of familiarity and frequency of use variables across Italian, Dutch, and Croatian samples and three age groups

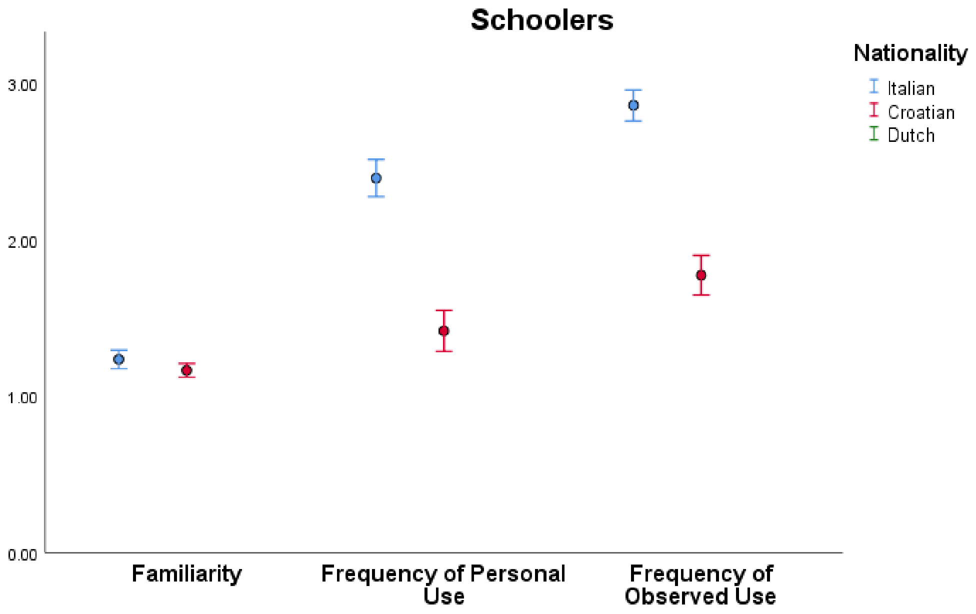
A Generalized Linear Model (GLzM, Nelder & Wedderburn, 1972) with Normal distribution and Power-log link function have been applied. The three nationalities were between factors. Familiarity was the dependent variable. Age, frequency of personal use and frequency of observed use were covariate variables. The detailed description of each GLzM is reported below.

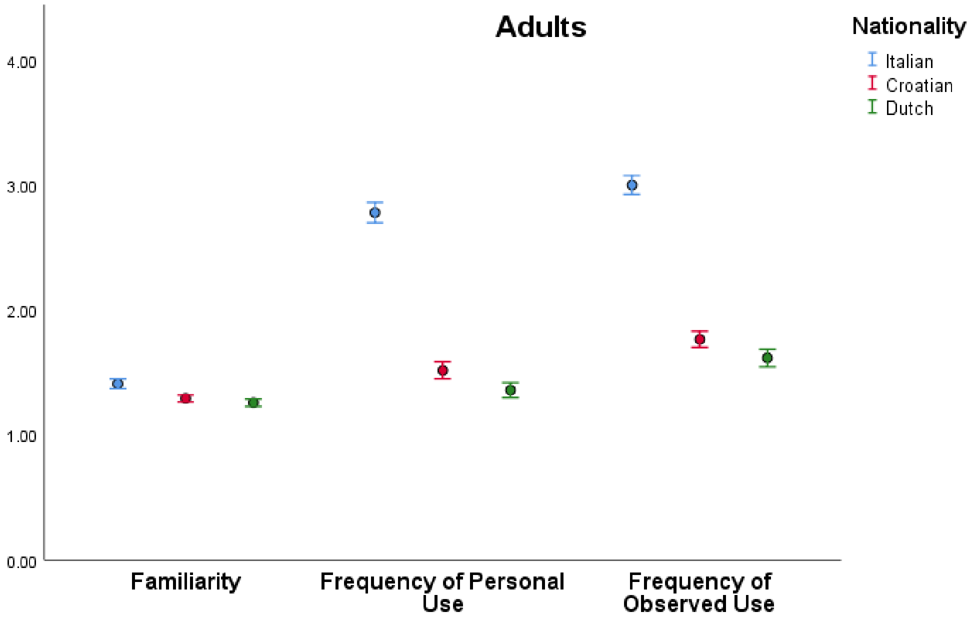
The main effect of nationality was not significant with Wald Chi-Square= .346, df 2, $p= .841$. The main effect of age was significant with Wald Chi-Square 5.05, df 1, $p < .025$, as was the main effect of frequency of personal use, Wald Chi-Square 7.64, df 1, and $p=.006$ and the frequency of observed use, Wald Chi-Square 16.49, df 1, and $p <.001$. The interaction between nationality and age was not significant with a Wald Chi-Square 1.08, df 2, and $p=.581$, as was the interaction between nationality and frequency of personal use, Wald Chi-Square 1.62, df 2, and $p=.443$, and the interaction between nationality and the frequency of observed use, Wald Chi-Square 1.22, df 2, $p=.541$. The interaction between age and frequency of personal use was significant, Wald Chi-Square 3,95, df 1, and $p= .047$. Whereas the interaction between age and frequency of observed use was not significant, Wald Chi-Square 2.08, df 1, $p= .148$. The interaction between frequency of personal use and frequency of observed use was significant with Wald Chi-Square 9,5, df 1, and $p= .002$. The interaction among nationality, age and frequency of personal use was not significant with Wald Chi-Square 3.85, df 2, and $p =.146$, as was the interaction among nationality, age and frequency of observed use, Wald Chi-Square .78, df 2, and $p= .676$, and the interaction among nationality, frequency of personal use and frequency of observed use, Wald Chi-Square .65, df 2, and p= .722. The interaction among age, frequency of personal use and frequency of observed use was significant with Wald Chi-Square 4.45, df 1, and p= .035. The interaction among all variables was not significant with Wald Chi-Square 2.32, df 2, and p =.313.

Figure 3 illustrates the interaction among object familiarity, frequency of personal use and frequency of observed use, across the three age groups and the three populations. As shown in the graphs, no difference in familiarity across children and adults came out. While a difference in frequency of personal and observed use in Italian occurred compared to the other two populations.

Figure 3. Interaction among object familiarity, frequency of personal use and frequency of observed use of Italian, Croatian and Dutch populations, across preschoolers (top panel), schoolers (middle panel) and adults (bottom panel)




Schoolers
Nationality
Italian
Croatian
Dutch
3.00
2.00
1.00
0.00
Familiarity
Frequency of Personal Use
Frequency of Observed Use


Adults
Nationality
Italian
Croatian
Dutch
4.00
3.00
2.00
1.00
0.00
Familiarity
Frequency of Personal Use
Frequency of Observed Use

General discussion

In this study, the results of the correlation between Italian data of Familiar And Novel Stimuli (FANS) Database and Croatian and Dutch ones are presented. These demonstrated that factors such as sociocultural dynamics may affect the perception of objects. Data were collected for familiarity, naming, function, using and frequency of use for the same objects used to create the FANS Database, for Dutch and Croatian populations, preschoolers, schoolers and adults. The procedure followed was identical to that applied for the Italian participants, in order to obtain the same information from Dutch and Croatian samples.

The first finding concerns the classification of objects into three categories, high, medium, and low in familiarity, frequency of personal use, and frequency of observed use for three different developmental stages. To the best of our knowledge, no database so far has proposed a classification like this. This classification can allow Dutch and Croatian researchers who will decide to refer to this database for the choice of the stimuli to clearly recognize which objects are known and which not in the age group of interest, choosing the appropriate ones in their studies that include participants of several ages.

The second finding regards the correlation among Italian, Croatian, and Dutch familiarity, frequency of personal use and use seen by others. Results showed that, regardless the age, differences are particularly evident in frequency of personal and observed use in Italian populations compared to the other two populations. In general, this suggests that culture has an important impact not on object familiarity but on object use, and that the effect is evident at any age. Specifically, this revealed that this set of objects has little differences in objects familiarity in the three populations. These differences particularly refer to the objects that are on the border between one level of familiarity and another. In contrast, the objects of this database are more personally used and seen to be used by others by Italian population and less by Croatian and Dutch ones, suggesting that the reliability of this set, regarding the frequency of use variables, is greater for the Italian population than for the Croatian and Dutch ones.

Compared to existing database, this set of objects has its limitations, i.e., the number of stimuli and the sample. At the same time, it provides norms for different languages using a parallel protocol. Future perspectives include the collection of norms for further items and further populations. In addition, Croatian and Dutch norms for name and function agreement will be measured. Finally, the level of awareness and intuition of participants will be examined. Namely, the interest is to determine to what extent participants are aware that their responses deviated from the standard way in which the objects were named and used. As for the Italian data, a double coding criterion will be used to achieve information on this, adopting a more analytical and more qualitative coding criterion (see Coding Criteria 1 and 2 in Chapter 3). The analysis related to the latter will be performed to improve response reliability across the age groups and investigate the level of awareness of participants in their familiarity judgments. The idea is that, as for Italian data, a higher level of awareness in older participants and a lower one in younger children occur. This will be assessed by measuring the use of alternative answers in naming and function questions by the first age group, and the use of intuitive answers in naming and function questions by the older age group.

Overall, these findings provide useful information for researchers who intend to study known and non-familiar objects and their variations in familiarity and frequency of use across ages (from preschoolers to adults) and populations (Italian, Croatian and Dutch). Specifically, these objects are particularly well suited for studies in which participants must not have prior knowledge, for experimental memory, perception, categorization, and other areas of cognitive research. Furthermore, these data highlight the importance of identifying stimuli that are appropriate not only for the goals of a study, but also for the combination of cultural and age variables.

CHAPTER 5

STUDY 3: CHILDREN ARE MORE RESPONSIVE TO FUNCTION KNOWLEDGE THAN ADULTS IN INTERACTING WITH FAMILIAR AND NON-FAMILIAR OBJECTS

Introduction

The environment is filled with countless objects. Each object has its specific function and its way of use. The indications on how to grasp and act with objects come mainly from their visible structure, in particular from their invitations and constraints of action, namely from their affordances (Gibson, 1977; 1979). Affordances can tell us how to move an object, whether something can fit into its grooves, whether there are fixed or moving parts, and whether all this information could be potential constraints that limit possibilities for action. (Norman, 1997). As reported by Gibson, this information is directly perceived with no need to activate our previous experiences with the object and knowledge of its function.

Over the last twenty years, several studies have focused on the Embodied Cognition theories, the views according to which cognitive processes are grounded in perception and action through a body that interacts with the environment (Barsalou, 1999; 2008). Depending on which embodied perspective is accepted, i.e., whether less or more radical, different views on affordances has been emerged: one emphasizes primarily the importance of experience and perception (Gibson, 1979), another one the prominence of body and action (Rosenbaum et al., 1990; Ellis and Tucker, 2000). Specifically, while Gibson described an ecological perspective of the theory, according to which the environment directly offers to us the possibility to correctly perceive object information without the mediation of mental representation, Ellis and Tucker and Rosembaum and colleagues claimed that affordances are the result among our previous experiences, the environmental stimuli, and the goal suggested by these.

Depending on what affordances elicit, authors have been categorized these into different types. Ellis and Tucker (2000) proposed the term “microaffordances”; Riggio and colleagues (2006), Borghi and Riggio (2009), and Pellicano and collaborators (2010) focused their attention on multiple affordances; Buccino and associates (2009) explored broken affordances; Kaufmann and Clément (2007) and Ferri and others (2010b) deepened into the social dimension of affordances; Anelli and associates (2013a; 2013b) dealt with dangerous objects; Borghi and Riggio (2015) suggested the distinction among stable, canonical and variable affordances; Jax and Buxbaum (2010) studied the conflicting actions evoking by objects identifying structural and functional information. In this study the attention was focused on this latter distinction. Jax and Buxbaum, when classifying affordances based on the structural properties (e.g., shape, size, orientation) and on the functional information (i.e., on the use) of an object, associate objects with two action classes: grasping in accordance with their structure and grasping consistent with their function. Since these two action classes may or may not be applicable for the same object, the authors conceptualized objects as conflict and non-conflict. The first are objects with competing structure and function responses, e.g., a blender is associated with different actions for structural and functional responses (i.e., clench to grasp, poke to use); while the second are objects associated with the same grasp action response, e.g., a screwdriver (clench to grasp and use). Interestingly, Jax and Buxbaum conducted an analysis on initiating actions by comparing common conflict and non-conflict objects. They asked participants to perform two tasks: a grasp task where they had to place the hand on the objects as they would to pass them to someone, and a use task where they had to place the hand as they would to use them. In particular, half of the participants were asked to perform first the use and then the grasp task; the residual participants were asked to perform the tasks in the opposite order. Analysing the initiation times, the authors found that, in general, grasp responses were faster than those related to the use; they then noted that grasp actions toward the conflict objects were longer when the grasp task was presented after the use task; finally, they observed slower reaction times during the use responses toward conflict objects independently of the task order. The general interpretation was that functional responses involve the activation of long-term conceptual representations, while grasp responses do not. These results confirmed that the activation of affordances is automatic, but also emphasized the necessity to activate our object representations to guide the actions.

An aspect that has been investigated as linked to object use is the functional fixedness. Duncker (1945) used the expression to refer to a situation in which a person cannot think of using an object in a new function that is required to solve a problem. Specifically, the author tested adult participants with the task of mounting three candles to a door such that they would not drip on the table below. Participants were provided with three candles and three boxes, among other distracter objects. The solution required tacking the boxes to the door as platforms for the candles. Results showed that more than half of the subjects failed to solve this task, presumably because they were fixated on the function of the boxes as containers, instead of considering the atypical function of platforms.

Although the concept of functional fixedness has been widely investigated in adults, research on children has been few. For example, the study by German & Defeyter (2000) tested children of 5-, 6-, and 7-year-olds with a problem-solving task analogous to Duncker's candle problem. Children were told a story in which a toy bear needed to reach a high shelf in a toy house. Findings revealed that older children were fixed on the box's function as a container, failing to consider the use of platform. Later, Defeyter and German (2003) investigated why younger children would be less functionally fixed than older children by testing the hypotheses that a) younger children would think more fluidly about object function than older children, b) younger children have scarce knowledge about the typical functions of objects. The authors concluded that younger children had greater functional fluidity and not deficient function knowledge of object. An opposing point of view suggested that even infants were sensitive to object function and associated functions with particular objects. Futó and colleagues (2010) used an object individuation paradigm to investigate 10-month-old infants' intuitions. The authors found that, like adults, infants associated a specific function to define one specific object. Similarly, Hunnius and Bekkering (2010) found that young infants associated given objects with particular functions. They showed videos of adults performing typical and non-typical actions with everyday objects to 6-, 8-, 12-, 14-, and 16-month-old infants. Results showed that infants of all age were faster in typical function-object association (e.g., phone to the ear) than non-typical association (e.g., phone to mouth).

As this short overview suggests, many studies so far have focused on the role played by structural and functional information during object recognition and on their neural underpinnings. However, to the best of our knowledge no study has focused on the different activation of object information (structural vs. function) depending on the age and on the level of object familiarity (familiar vs. non-familiar). In addition, although the aspect of functional fixedness has been widely documented in adults, research on children has been few and conflicting. Furthermore, to the best of our knowledge, no evidence so far with preadolescents has been collected. In view of this, the aim of this work was to investigate whether younger children are less bounded to functional fixedness than older children, preadolescents and adults when interacting with objects. Crucially, among stimuli, there are non-familiar stimuli, i.e., unknown or little-known objects by participants were selected. The importance of the variable of the novelty is crucial in a variety of situations and has been demonstrated in word learning (e.g., Horst & Samuelson, 2008; Yu & Smith, 2007), categorization (e.g., Homa et al., 2011; Bornstein & Mash, 2010; Smith & Minda, 2002), object recognition (Smith, 2003; Hummel, 2000). Here, real familiar and non-familiar objects, namely everyday objects of two levels of familiarity (less and more familiar) and belonging to several categories (e.g., kitchen utensils, office supplies, household articles) were chosen. Participants from 3 years old to adulthood were asked to manipulate objects. The focus was on the structural and functional affordances. Object manipulating were coded into three ways: structural, functional, and alternative grasping. The latter was crucial to verify the level of functional fixedness. Only the first macro action during manipulation was coded. Given the existing literature, assumptions viewed both children and adult's manipulation of familiar objects more structural than functional. Regarding less familiar objects the expectations were the same since object knowledge are poor. As for the alternative manipulation, since the results of the previous work (see Chapter 3) saw younger participants more creative in giving alternative answers to object functions, the hypothesis was that the use of the third kind of manipulation was higher in children than in adults, suggesting that children are less bounded to functional fixedness than adults while manipulating objects.

Method

Participants

Participants were recruited from the University of Bologna and from a school that includes a kindergarten, a primary school, and a secondary school. A total of 127 participants (3-45 years old) voluntarily participated in the study (73 females, 22 left-handed, MAge: 10.6, SDAge: 6.8). It was necessary to exclude 9 participants due to the following reasons: 3 undergraduate students who contributed to the pilot version of the study useful to test the procedure; 4 participants who presented cognitive abilities not assessed in this study. Therefore, the final sample included 121 participants (68 females) divided as follows: group 1 – kindergarten children, 21 participants from 3 to 5 years old (10 females); group 2 – children of Primary School, 57 participants from 6 to 10 years old (33 females); group 3 – preadolescent of Secondary School, 22 participants from 11 to 13 years (12 females); group 4 – undergraduate students, 21 participants from 18 to 40 years old (13 females). All were Italian speakers with normal or corrected-to-normal vision. Before starting the experiment, undergraduate students and their parents for minors provided their written informed consent. The Ethics Committee of the University of Bologna approved the experimental protocol (Approval number: Prot. 78991, 8.6.2018).

Materials

The stimuli consisted of 18 everyday objects selected from the Familiar And Non-Familiar Stimuli (FANS) Database (see Chapter 3) that classifies objects according to their familiarity and frequency of use from childhood to adulthood. The stimuli selected belonged to two levels of familiarity (nine objects for each level), namely more (e.g., clothespin) and less familiar (e.g., thumb book holder). All were of small size to facilitate their use during the manipulating task. Different structural and functional object properties and texture were considered in stimuli selection (see Table C1 in Appendix C).

Procedure

Participants were asked to take part in an experimental session consisting of a manipulating task of 40 sec. Each interview was conducted with a single person. Undergraduate students were interviewed in the Cognitive Psychology Lab of the University of Bologna. Children and pre-adolescents were interviewed in their kindergarten or school in a quiet room, suitably set up to grant them a familiar environment. Each session was videotaped with a Sony HDR-CX240E camcorder. In defining the frame of the video, the faces of participants were avoided to ensure anonymity.

Participants were sitting on a chair next to a desk and were presented with the objects.

Manipulating task. Participants were asked to interact with objects with the specific request "*Do what you want with this object!*".

See Appendix C for examples of object manipulation by children, preadolescents, and adults with more and less familiar objects.

Analysis

Coding

Object manipulation was coded according to three different types of action:

- *Structural*: action in accordance with object structure;
- *Functional:* action consistent with object functions;
- *Alternative*: action in accordance with non-conventional functions of objects.

The focus was on the first macro action performed.

Results

A preliminary Correspondence Analysis (CA) was conducted on 63 participants (37 females) to explore the relationship between three age-ranges (6-7/11-13/>18 years old) and three different kinds of object manipulation (structural, functional, alternative) of three familiar (i.e., bottle, wrench, sponge) and three less familiar objects (i.e., fruit cutter, tube squeezer, thumb book holder). Table 1 shows the correspondence data. Figure 1 shows the correspondence analysis between age groups and manipulation types on two dimensions. Specifically, on:

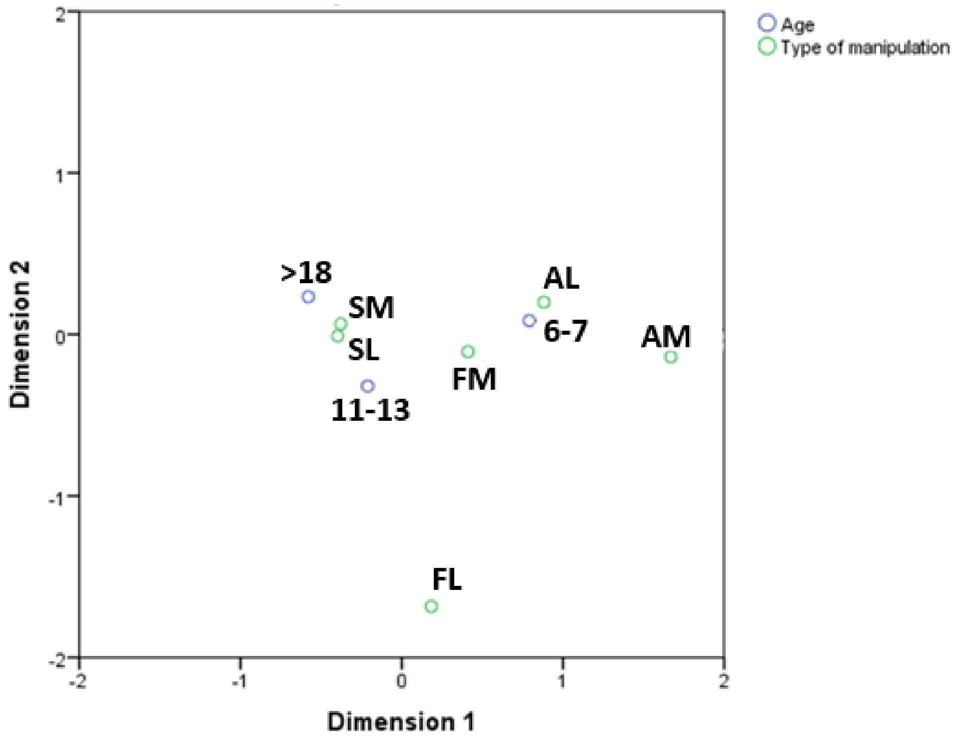
- Dimension 1: 6-7 age group opposed to adult group; children were mostly associated with alternative actions when manipulating less familiar objects, while adult group was mostly associated with actions concerning the structure when manipulating more and less familiar objects.

- Dimension 2: children group opposed to preadolescent group; children were mostly associated with functional actions when manipulating more familiar objects, while preadolescents were mostly associated with structural actions when manipulating more and less familiar objects.

Table 1. Correspondence Table

Age	More familiar object manipulation			Less familiar object manipulation		
	Structural	Functional	Alternative	Structural	Functional	Alternative
6-7	28	25	10	29	2	32
11-13	42	18	3	46	3	14
>18	49	14	0	52	1	10
N	119	57	13	127	6	56

Figure 1. Correspondence Analysis between age groups and manipulation types



Legend:
SM= Structural grasp/More familiar objects
FM= Functional grasp/More familiar objects
AM= Alternative grasp/More familiar objects
SL= Structural grasp/Less familiar objects
FL= Functional grasp/Less familiar objects
AL= Alternative grasp/Less familiar objects

Two chi-square tests of independence on the whole sample were performed to examine the relation between age groups and the kind of manipulation during more familiar object manipulation and less familiar object manipulation. The relation between the variables during more familiar object manipulation was significant with chi-square statistic= 51.59 and p= <0.001 (see Table 2). The relation between the variables during less familiar object manipulation was significant with chi-square statistic=140.33 and p=

<0.001 (see Table 3). Specifically, as Figure 2 shows, children from 3 to 5 years old preferred functional grasping during more familiar object manipulation, while participants from 6 to adulthood mostly performed structural grasping. Alternative actions were particularly used by younger participants. Figure 3 shows less familiar object manipulation. Interestingly, children from 3 to 5 years old mostly chose alternative actions, while the other age groups preferred actions concerning the structure of the objects.

Table 2. Chi-square correspondence table of more familiar object manipulation

Results more familiar object manipulation				
Age group	**Structural actions**	**Functional actions**	**Alternative actions**	**Row Totals**
3-5	61 (92.50) [10.73]	84 (74.28) [1.27]	44 (22.21) [21.36]	189
6-10	278 (251.08) [2.89]	177 (201.62) [3.01]	58 (60.30) [0.09]	513
11-13	95 (96.91) [0.04]	85 (77.82) [0.66]	18 (23.27) [1.19]	198
>18	99 (92.50) [0.46]	82 (74.28) [0.80]	8 (22.21) [9.10]	189
Column Totals	533	428	128	**1089 (Grand Total)**

Table 3. Chi-square correspondence table of less familiar object manipulation

Results more familiar object manipulation				
Age group	**Structural actions**	**Functional actions**	**Alternative actions**	**Row Totals**
3-5	65 (105.35) [15.45]	34 (47.03) [3.61]	90 (36.62) [77.81]	189
6-10	307 (285.94) [1.55]	114 (127.66) [1.46]	92 (99.40) [0.55]	513
11-13	117 (110.36) [0.40]	60 (49.27) [2.34]	21 (38.36) [7.86]	198
>18	118 (105.35) [1.52]	63 (47.03) [5.42]	8 (36.62) [22.37]	189
Column Totals	607	271	211	**1089 (Grand Total)**

Figure 2. Relation between age groups and the kind of manipulation during more familiar object manipulation

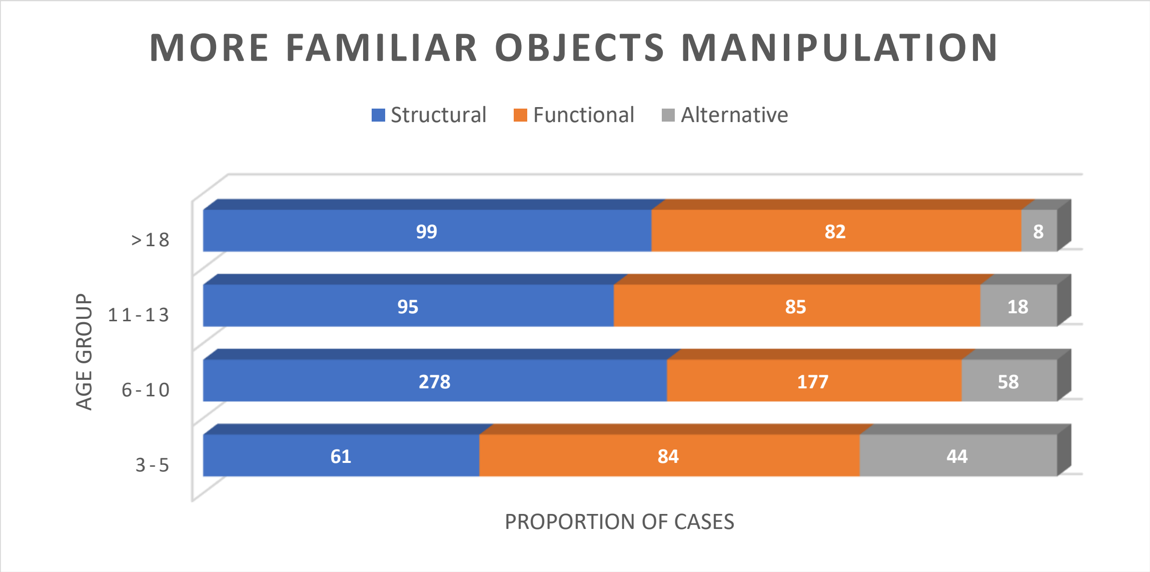
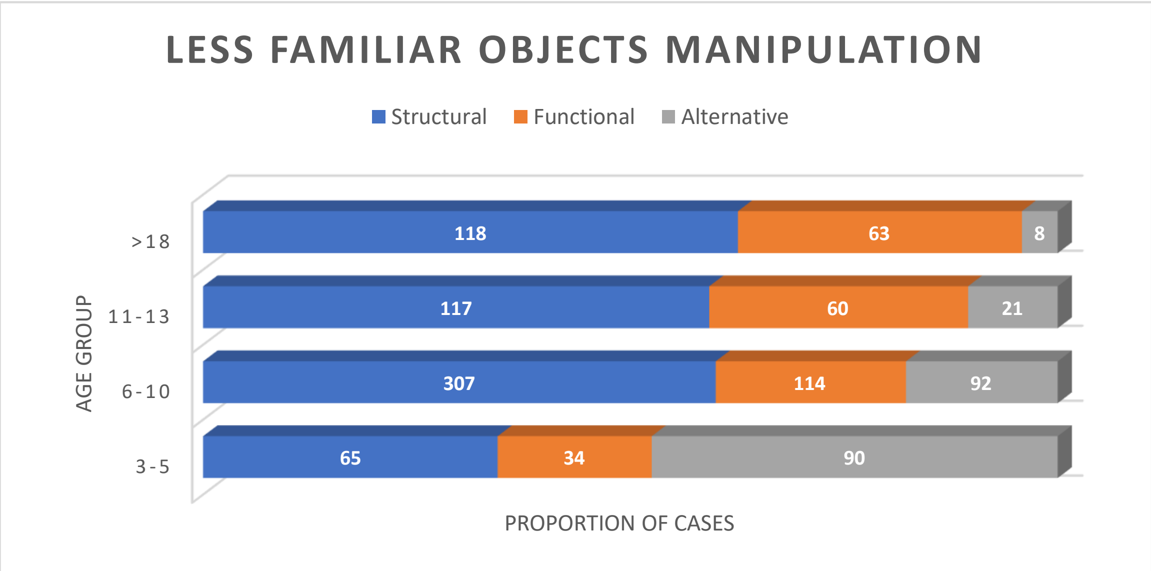


Figure 3. Relation between age groups and the kind of manipulation during less familiar object manipulation



General discussion

In this study, new findings on the important role of experience and of age in responding to objects' affordances and to objects' function are presented. The study aimed to investigate the kind of knowledge elicited while manipulating more and less familiar objects. Specifically, the focus was to determine whether children are less bounded to functional fixedness than adults when interacting with more and less familiar objects. Participants underwent a session of object manipulation. They included two groups of children, one from 3 to 5 years old, the other from 6 to 10 years old, a group of preadolescents, and adults.

The object information investigated were those structural and functional. Structural and functional information were coded as associated with specific classes of action, i.e., actions in accordance with object structure, actions in accordance with the use of the object. In this study, besides structural and functional actions, alternative actions were considered. Specifically, these are actions in accordance with non-conventional functions of objects.

The first results of this study came from a preliminary analysis conducted on three age groups (i.e., children from 6 to 7 years old, preadolescents and adults) and three more familiar objects and three less familiar objects. Overall, these first set of data demonstrated that all age groups were more responsive to structural features during the manipulation of more familiar objects. However, considering the proportion of children and preadolescents' responses compared with those of adults, functional grasps were lower by very little. As for the alternative actions, these were most used by children. With regards to the manipulation of less familiar objects, findings showed that children mostly used alternative actions, while preadolescents and adults the structural ones.

The analysis conducted on the whole sample partially confirmed these results. Specifically, from the 6 year of age to adulthood, overall participants preferred structural actions when they interacted with more familiar objects. However, the discrepancy between structural and functional responses in preadolescents and adults was extremely low. Interestingly, children from 3 to 5 years old mostly performed functional responses. As for the alternative actions, these were mostly adopted by the youngest group. During the manipulation of less familiar objects, adults, preadolescents and the second group of children mostly adopted structural actions. Interestingly, alternative actions were strongly dominant in the first age group. These results confirm in part the findings of the study by Jax and Buxbaum in which adults reached faster initiating times in reacting to structural information during the manipulation of familiar objects. Here, this phenomenon also occurred in children from 6 years old and preadolescents. The innovative result concerns the youngest group of children. Surprisingly, this group compared to older children, preadolescents and adults were mostly responsive to functional information during more familiar object manipulation, adding an important insight to the literature of affordances from a developmental point of view.

Another interesting result refers to the alternative actions, particularly dominant in the youngest children. This finding is especially important for the phenomenon of functional fixedness. Two views contend the camp in literature: according to the first, younger children are less functionally fixed than older children due to a greater functional fluidity and not to a deficient function knowledge of object. The opposing view proposes that infants are sensitive to object function and associate specific functions with particular objects. Here, the results support partially both perspectives. Specifically, the fact that the first group of children mostly adopted alternative actions during less familiar object manipulation may be justified by the lack of function knowledge of the objects. However, although to a lesser extent, the youngest children also used alternative responses during more familiar object manipulation, suggesting that the phenomenon is not totally linked to a lack of knowledge, rather to a low functional fixedness and a high creativity. The dominance of functional responses by the youngest children during more familiar object manipulation, instead, may be associated with the second perspective but further research will be useful to clarify the incidence.

In conclusion, the results of this study add interesting insights to the literature of affordances. These suggest the important role of experience and of age in responding to objects' affordances and to objects' function. It was argued that younger children as compared to older children, preadolescents and adults are more responsive to function knowledge. In addition, independently of the right recognition of less familiar object they adopt more frequently alternative and creative action responses, identifying new functions of the objects.

CHAPTER 6

STUDY 4: TOYS ARE MORE FAMILIAR THAN DOLLS. OBJECT FAMILIARITY AND HIERARCHICAL LEVEL OF CATEGORIZATION

Introduction

The last twenty years have assisted in the spread of behavioral and neural studies investigating the grounding in sensorimotor experiences of "higher" cognitive processes such as language and categorization (e.g., Barsalou, 1999a; Gallese & Lakoff, 2005). The most influential theoretical approach is the embodied view, according to which cognition is grounded in perception and action through the body that interacts with the environment (Barsalou et al., 2018; Bidet-Ildei et al., 2020 and Borghi, 2020 for reviews). While according to more radical views, the body is central for cognition, grounded cognition views propose that cognition is not necessarily grounded in bodily states but also in simulations of non-present situations and, more generally, in situated experiences (Gallese & Goldman, 1998; Barsalou, 1999; Barsalou et al., 2008). The present work adopts an embodied and grounded cognition perspective and focuses on object categorization. Specifically, it concentrates on more and less familiar objects and examines how their categorization varies across development.

Before delving into how object concepts are categorized, defining what concepts are and describing why they are essential is necessary. According to Murphy (2002), concepts represent the key ingredients of our thought through which we build new knowledge. He characterized them as a sort of glue that holds together past, present, and future experiences. Through concepts, we can understand and organize the world around us: we will know how to use objects, how to interact with others, how to move in space (Caruana & Borghi, 2016). As per the embodied cognition view, concepts consist of the reactivation of the neural pattern that occurs when we experience objects, entities, situations (Barsalou, 1999). For instance, the concept of "fork" will be formed by the reactivation of the neural pattern activated when we experience it, e.g., when we eat and when we see someone using it. Thus, concepts are based on perception, action, and emotions and aim at acting (Borghi, 2005).

Concepts can be more or less general and are connected through multiple relations. Here the focus is on a) at which level categorization is organized, i.e., whether at a superordinate, basic or subordinate level (e.g., animal, dog, bulldog); b) in which way concepts combine with one another, i.e., whether thematically, partonomically, or taxonomically, and c) which are the most relevant information during objects categorization, i.e., whether the manipulative or functional one. These three issues will be addressed in turn.

To understand how categorization is organized, we need to go back to the late 1970s when a group of psychologists (Rosch et al., 1976) demonstrated that humans classify categories in taxonomic levels, and specifically into three hierarchical levels: superordinate, basic, subordinate. To give an example, going from the more to the less inclusive level: “kitchen utensil” is the superordinate of “fork” that is the basic level category of the subordinate “dessert fork”. Many studies focused on babies and young children, since infancy until late childhood is the period when novel instances about objects, people, events are acquired, but there is also various evidence on adults (Rosch et al., 1976; Bornstein, 1984; Rakison & Oakes, 2003; Bornstein & Arterberry, 2010). Two contrasting views differently explain the conceptual acquisition. According to the first view, children acquired first the basic-level categories, which are also the most used by adults (Rosch et al., 1976). Then, between ages 4 to 5, children learn to use the superordinate level-categories (Markman & Callanan, 1983); the subordinate one is the last to be formed over the years (Mervis & Crisafi, 1982). Another point of view does not see basic-level categories as the first kind of categories to develop. Several studies (Mandler & Bauer, 1988; Mandler, 1992a; 1992b; 1993; Mandler & McDonough, 1993; Mandler, 2008; Bornstein & Arterberry, 2010; Shylaja & Manjula, 2016) show that children spontaneously use superordinate categories as already in the first year of life. Later, they learn to categorize at a basic level, even later at a subordinate one.

Regarding the way concepts combine, the most investigated relationships are the thematic, partonomic, and taxonomic ones. Concepts are thematically related when co-associate with events, space, time, objects, agents, e.g., dog-bone, swallow-spring, dog-barks (Markman 1981; 1989; Lucariello et al., 1992; Lin & Murphy, 2001; Lawson et al., 2017). Partonomic or meronymic relations refer to part-whole associations (e.g., fruit-seed). Finally, concepts are taxonomically related when linked by relationships of subordination, sovraordination, or coordination (Borghi & Caramelli, 2003; Sass et al., 2009; Mirman, 2017). The primacy of one relationship over another has also been studied, especially in developmental research. Most of the evidence suggests that preschoolers use more thematic than taxonomic relations (Markman & Callanan, 1983), possibly because young children are unable to form taxonomical classes (Lin & Murphy, 2001). Between ages 4 and 8, there is a developmental shift from the thematic to taxonomic level, likely driven by schooling (Markman 1981; 1989; Carey, 1985; Jones & Smith, 1993; Sheya & Smith, 2006). According to other views, thematic and taxonomic relationships coexist since the early stages of development (Bauer & Mandler, 1989; Osborne & Calhoun, 1998), and adults continue to use both kinds of relations. Thus, even young children are able to make use of taxonomic categories. A study with children aged 5, 8, and 10 (Borghi & Caramelli, 2003) shows that, at all ages, thematic relations outnumber taxonomic ones, in contrast with the idea of a thematic-to-taxonomic shift. Interestingly, the same study offers an analysis of thematic categories, showing that at five children use more functional and temporal relations, whereas, in older children, spatial relations are more frequent. Despite some contrasting evidence (Tare & Gelman, 2010), many studies converge in showing that thematic organization is pivotal not only for children but also for adults' conceptual organization. Evidence reveals that adults can easily categorize objects both thematically and taxonomically (Estes et al., 2011), that they tend to sort objects more thematically than taxonomically (Lawson et al., 2017) and that they use thematic relations for sorting, induction, and category membership verification (Lin & Murphy, 2001; Murphy, 2001; 2002). Experiments on partonomic relations are not abundant. The most interesting one, and the most pertinent for this study, shows that children (4-6-8-10 year-olds), during a free production task, count more parts if the stimulus is a picture rather than a noun. Parts are relevant from both the structural and functional point of view, both for children and adults (Tversky, 1989; Borghi 1997).

As to the most relevant information related to interacting with objects, research has mainly investigated two properties: structural (or volumetric) information and function knowledge (Buxbaum et al., 2000; Bub et al., 2008; Jax and Bubaum, 2010).

Structural information is linked to visual features and the gestures useful to hold and use objects, e.g., a fork is held in hand to obtain food from a dish. Function knowledge concerns the use of an object, e.g., the fork is used to eat. Studies have focused on whether categorization is based primarily on one of these two types of information. The earliest evidence was collected to investigate the distinction between living and non-living categories in patients with brain lesions (Warrington & Shallice, 1984). Results showed that functional features were more relevant than visual ones for categorization. A study with healthy adults (Garcea & Mahon, 2012) demonstrates that participants have faster reaction times when accessing function than structural information. Significant for the interest in developmental research, a more recent study on 8-9-10-year-old children and adults (Collette et al., 2016) reveals that, during naming familiar objects, children rely on structural features more than adults, who instead favoured functional knowledge. Between 8 and 10 years of age, a slight decrease in structural information occurred, whereas no difference between 10-year-olds and adults was evident.

As this overview suggests, much evidence has focused on hierarchical levels (superordinate, basic, and subordinate ones) and conceptual relations (thematic, partonomic, and taxonomic ones) in the categorization of familiar objects in infants, older children, and adults. Studies on the role of structural and functional information across developmental stages are, instead, not many. In both research areas, the studies using non-familiar objects are only a few. The aim of our work was to investigate whether children's (from 3 to 6 years and from 7 to 9 years), preadolescents' (from 10 to 13 years) and adults' interaction with objects of different familiarity (less and more familiar) changes in terms of categorization level (superordinate, basic and. subordinate level), conceptual relations (thematic, partonomic, and taxonomic relations) and object information (structural vs. function knowledge). Crucially, an aspect taken into account by very few studies (e.g., Smith, 2003; Borghi et al., 2011) was considered: the selection of non-familiar stimuli, i.e., unknown or little-known objects by participants. The importance of this variable is crucial in a variety of situations and has been demonstrated in word learning (e.g., Horst & Samuelson, 2008; Yu & Smith, 2007), categorization (e.g., Homa et al., 2011; Bornstein & Mash, 2010; Smith & Minda, 2002), object recognition (Smith, 2003; Hummel, 2000), and object manipulation tasks. While authors of previous studies used non-real objects, specifically built for their purpose (e.g., grey caricatures in case of Linda Smith, 2003; or 3D invented figures in case of Borghi et al., 2011), real known and non-familiar objects were chosen, namely everyday objects of two levels of familiarity (less and more familiar) and belonging to several categories (e.g., kitchen utensils, office supplies, household articles).

Participants from age 3 to adults were asked to freely manipulate objects, respond to questions related to objects' familiarity, and, finally, name the objects and describe them. The questions on objects' familiarity were asked to ensure the degree of knowledge of objects. The naming task aimed to detect the level of object categorization (whether superordinate, basic, or subordinate). The free description aimed to identify the type of conceptual relations (whether thematic, partonomic, or taxonomic) and the occurrence of manipulative and functional information.

Given the existing literature on familiar objects, it has been hypothesized that younger children compared to older ones would categorize primarily at the basic or superordinate level (Bornstein & Arterberry, 2010; Shylaja & Manjula, 2016).

Furthermore, they should produce more thematic than other kinds of relations (Borghi & Caramelli, 2003). Regarding object information, younger children should be more bound to structural information than functional knowledge (Collette et al., 2016). As for adults, it has been assumed that: a. if category learning proceeds from basic to other levels, they should use less basic level categories than children (Rosch et al., 1976); b. if a thematic to taxonomic shift occurs, they should produce more taxonomic relations than younger children (Tare & Gelman, 2010); c. because, with the experience, people tend to associate each object to a specific function, adults should be more bounded to functional information than children (Garcea & Mahon, 2012). A higher use of partonomic relationships in younger participants has been argued, since not knowing the objects, they would focus more on the parts that constitute the whole objects to guess their functions.

Lastly, a deeper exploration including conceptual shades about superordinate categorization level and thematic and partonomic relations was carried out. Specifically, whether participants during superordinate categorization generally include a) nouns, e.g., tool, container (Wisniewski at al., 1996) or b) information regarding their function, e.g., a utensil that is used in healthcare (Tversky, 1989) was investigated. Then, whether participants while producing partonomic relationships a) name the parts of objects, e.g., there is a stick and two cotton balls or b) indicate the action associated with the parts, e.g., the handles rise and fall, was probed. Finally, which of agent, spatial, temporal, action, functional thematic relationships were more used was examined. Importantly, the performance of preadolescents, not yet explored in literature, with familiar and non-familiar objects was investigated to verify whether it was more similar to that of children or adults.

Method

Participants

Participants were the same recruited for the study in Chapter 5.

Materials

The stimuli consisted of 18 everyday objects selected from the Familiar And No-Familiar Stimuli (FANS) Database (see Chapter 3) that classifies objects according to their familiarity and frequency of use from childhood to adulthood. The stimuli selected belonged to two levels of familiarity (nine objects for each level), namely more (e.g., clothespin) and less familiar (e.g., thumb book holder). All were of small size to facilitate their use during the manipulating task. Different structural and functional object properties and texture were considered in stimuli selection (see Table 1 in Appendix D for the list of the more and less familiar stimuli).

Procedure

Participants were asked to take part in an experimental session consisting of a linguistic task preceded by a few seconds of object manipulation. Each session lasted a total of about 45 minutes. Each interview was conducted with a single person. Undergraduate students were interviewed in the Cognitive Psychology Lab of the University of Bologna. Children and pre-adolescents were interviewed in their kindergarten or school in a quiet room, suitably set up to grant them a familiar environment. Each session was videotaped with a Sony HDR-CX240E camcorder. In defining the frame of the video, the faces of participants were avoided to ensure anonymity.

Before taking part in the linguistic task, participants were asked to manipulate objects, one at a time, for 40 seconds. They were sitting on a chair next to a desk and were presented with the objects.

Linguistic task. Participants had to answer six oral questions: the same five questions selected to create the Italian Familiar and Non-familiar Stimuli (FANS) Database. Besides, participants were asked to describe the objects. Specifically, the questions are as follows:

1. *Familiarity.* "Do you know this object?". Participants were asked to answer "Yes" or "No" within 5 seconds.
2. *Naming.* “If yes, what is it? / If no, what it could be?”. If participants answered "Yes" to the previous question, they were asked to say the name of the object. If participants answered "No", they were asked to say the name it could have or to invent a name it might have - both within 20 seconds.
3. *Function.* “If yes, what’s it for? / If no, what could it be for?”. If participants answered "Yes" to the first question, they were asked to say the object's function. If they answered "No", they were asked to say the function it could have or to invent a function it might have, both within 20 seconds.
4. *Use.* “Did you use it yourself or did you see someone use it?”. Participants were asked to say whether they used the object or whether they had seen someone else use it within 5 seconds.

5. *Frequency of use.* “How often? Never/rarely/sometimes/often/very often”. We used two 5-point rating scales to rate both the personal use and the observed use, in which 0 indicated never, and 4 indicated very often.
6. *Description.* “Describe the object”. Participants were asked to describe objects within 40 seconds.

The first five questions (i.e., the *Familiarity*, *Naming*, *Function*, *Using*, and *Frequency of Use*) were asked to ensure the familiarity level of objects. The second one (*Naming*) aimed to detect the level of object categorization (whether zero, basic, subordinate, or superordinate). The last one (*Free description*) had the goal to identify the type of conceptual relationship (whether thematic, partonomic, or taxonomic) and the occurrence of structural and functional information.

No analyses were conducted on response time.

Analysis

Coding

The hierarchical level of the produced names, four different kinds of conceptual relations and two types of object information during the free description task were coded.

The object hierarchical levels were the following:

- Zero levels: participants do not provide a reply, do not know the reply, or cannot remember the object name, e.g., I do not know, I do not remember.
- Basic level: participants mainly provide basic level names and that mentioned perceptual properties (Markman et al., 1980; Bornstein & Arterberrry, 2010), e.g., a sponge; a fork.

- Subordinate level: participants produce compound names and include properties such as the color, the material ant the texture (Bierdman, 1987), e.g., a nutcracker; a binder clip.
- Superordinate level: participants generally include collective and countable nouns referring to the objects (Wisniewski at al., 1996) and function (Tversky, 1989), e.g., a tool; an object that is used in the kitchen.

The conceptual relations were:

- Zero relation: participants do not provide a reply.
- Thematic relations that include: a) agent relation (by whom?): the referent of the object-concept, e.g., my mum often uses a cotton swab; b) spatial relation (where?): the context referred to the object concept, e.g., I always use a paperclip at school; c) temporal relation (when?): the moment to which the object concept is related, e.g., I drink from my bottle after a run; d) action relation (what?): the action that the referent could do, e.g., I can open and close the handles of the binder pin; e) function relation (what for?): the function linked to the object concept, e.g., I use a fork to bring food to my mouth.
- Partonomic relations that include: a) 'part of' relation: the production of the parts forming the whole, e.g., there is a stick and two cotton balls; b) the action referred to the parts: the actions associated with the parts of the object, e.g., the handles rise and fall.
- Taxonomic relations that include the production of basic, subordinate, and superordinate concepts, e.g., it is a container for water; specifically, a plastic bottle with a pink tap.

The object information was:

- structural properties, e.g., it is small and blue; there is a hole in the middle.
- functional properties, e.g., it is used for eating; you can open the handles and bind the sheets.

Two persons coded the data. The percentage of agreement was 88%. Disagreements were solved after discussion.

Results

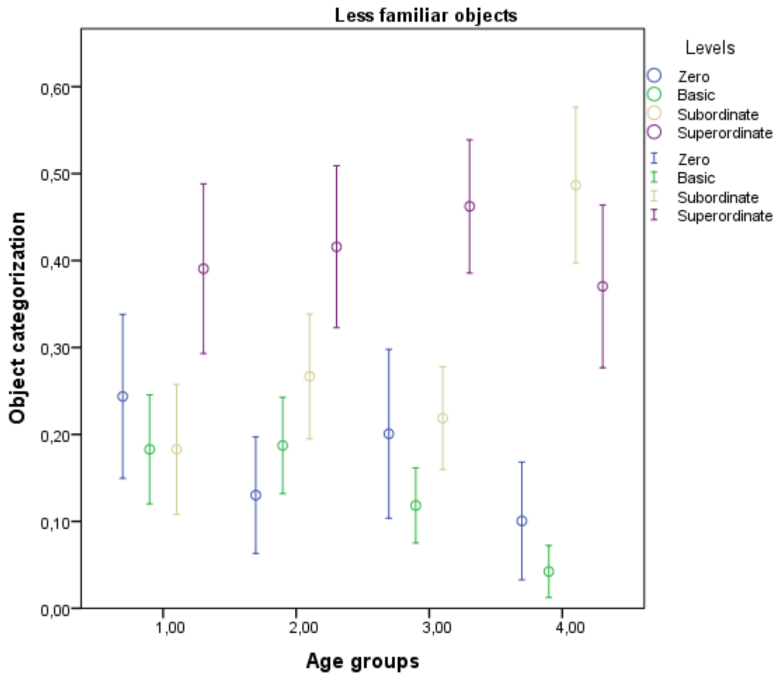
Overall, how children, preadolescents, and adults categorize familiar and non-familiar objects was investigated. Specifically, the sample is composed by children of different ages – from 3 to 6 years and from 7 to 9 years-, pre-adolescents (from 10 to 13 years) and adults (from 18 to 45 years), to whom objects of different familiarity, i.e., more familiar vs. less familiar were submitted. Participants' production in terms of object categorization level, i.e., basic vs. subordinate vs. superordinate, conceptual relations, i.e., thematic vs. partonomic vs. taxonomic, and object information types, i.e., structural vs. function knowledge was coded.

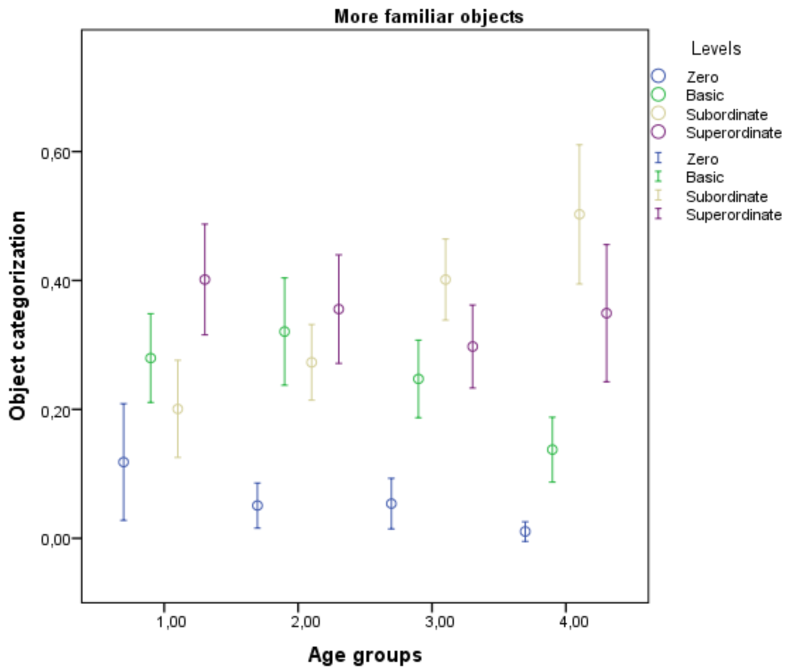
Six Generalized Linear Models (GLzM, Nelder & Wedderburn, 1972) with a Gamma-log link function have been applied. The age and the level of objects' familiarity were between subject factors. For each model, the dependent variable was: a. the occurrence of responses concerning the three levels of categorization (basic, subordinate and superordinate); b. the occurrence of responses of the three kinds of conceptual relations (thematic, partonomic and taxonomic); c. the occurrence of responses related to the subcategories of the superordinate categorization level (nouns and function); d. the occurrence of responses of the five subcategories of thematic relation (agent, spatial, temporal, action, function); e. the occurrence of responses concerning the two subcategories of partonomic relation (names of part and function elements of parts); f. the occurrence of responses related to manipulative or functional information.

Overall, the main effect of the individual variables and the interactions of these were significant. The detailed description of each GLzM is reported below.

Considering the types of object categorization, correlated with the age group and the level of object familiarity, the main effect of age was significant with Wald Chi-Square = 14.91, df 3, $p = .002$, as was the main effect of the types of object categorization, Wald Chi-Square (3) 97.79, $p < .001$. The main effect of the level of object familiarity was less significant with a Wald Chi-Square 2.18, df 1, and $p = .139$. The interaction between the age and the types of object categorization was significant, Wald Chi-Square 91,46, df 9, and $p < .001$, as was the interaction between the level of objects' familiarity and the types of object categorization, Wald Chi-Square 52.72, df 3, $p < .001$. The interaction among the age, the level of object familiarity, and the types of object categorization was close to significance with Wald Chi-Square 20,75, df 12, and $p = .054$. Figure 1 illustrates the effect of the age and the level of object familiarity on the four levels of object categorization. As shown in the graphs, the basic level of categorization decreases with increasing age, and no particular difference between less and more familiar objects came out. Subordinate concepts increase with increasing age and occur more for more familiar objects. The frequency of superordinate categories is relatively stable in all age groups with a higher concentration in the less familiar object descriptions.

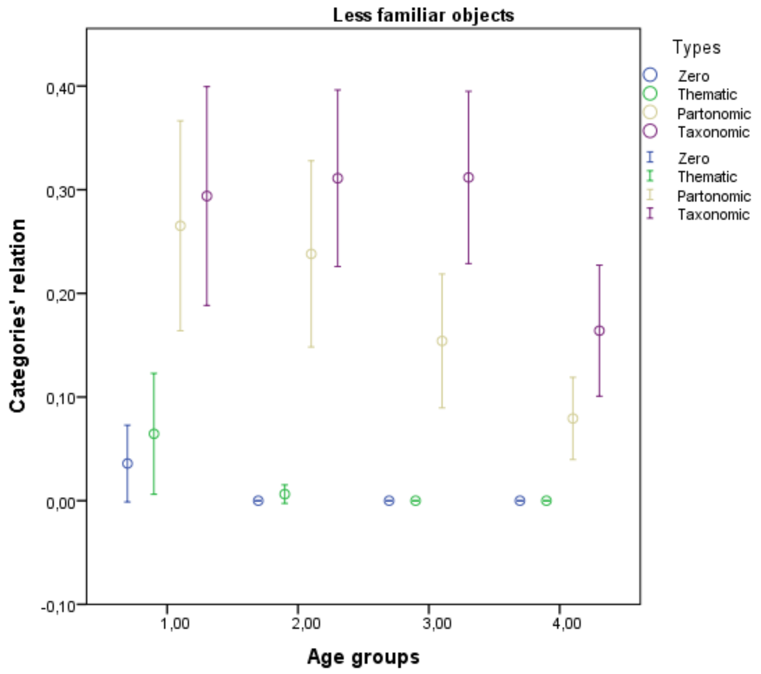
Figure 1. Graphs of the relation among the types of object categorization, age, and the level of object familiarity (top panel: high familiarity; bottom panel: low familiarity)

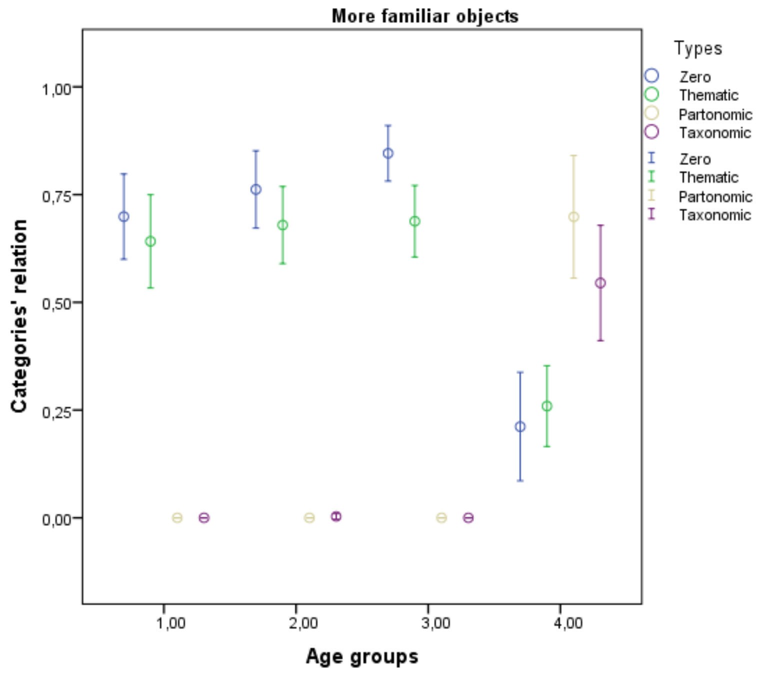




The analysis conducted concerning the interaction among conceptual relations, age, and objects' familiarity was also significant. The main effect of age was significant with Wald Chi-Square 65.34, df 3, $p < .001$, as was the main effect of the types of conceptual relation, Wald Chi-Square 211.50, df 3, $p < .001$. In contrast, the main effect of the level of object familiarity was not significant, with a Wald Chi-Square 0.24, df 1, $p= .622$. The interaction between the age and the types of conceptual relations was significant with Wald Chi-Square 273.50, df 5, $p < .001$ as was the interaction between the level of objects' familiarity and the types of conceptual relation, Wald Chi-Square 23.36, df 3, $p < .001$, and the interaction among the age, the objects' familiarity and the types of conceptual relation, Wald Chi-Square 13.08, df 6, $p= .042$. Figure 2 explains this interaction: the thematic relations decrease with increasing age, and they are mostly used for more familiar objects' description, especially by children; the partonomic relations also decrease with increasing age for less familiar objects' description, while they drastically increase with increasing age for the description of more familiar objects; finally, taxonomic relations decrease with increasing age for less familiar objects' description, but their frequency shows a substantial rise in adults' group for more familiar objects' description.

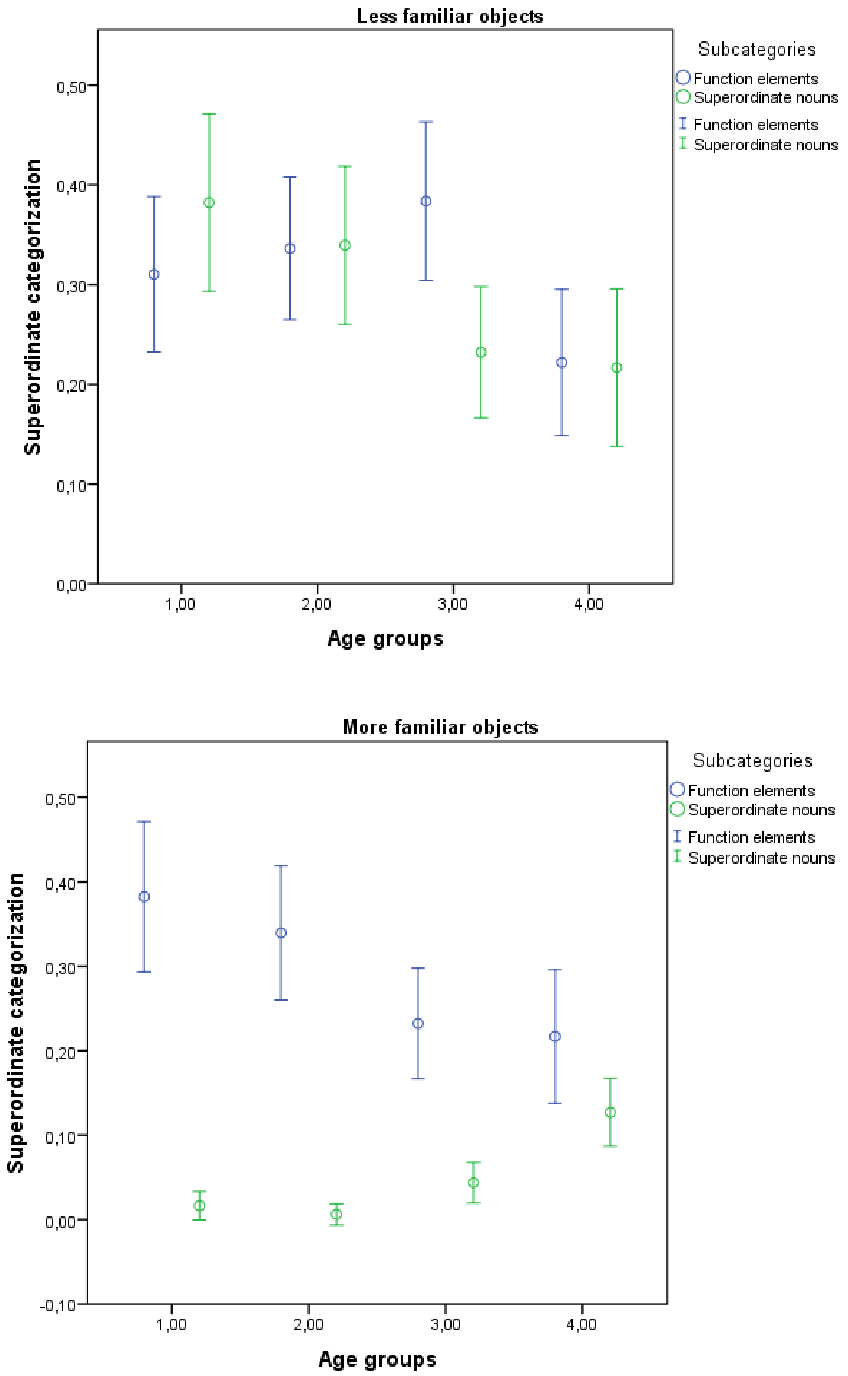
Figure 2. Graphs of the relation among conceptual relations, age, and objects' familiarity (top panel: high familiarity; bottom panel: low familiarity)





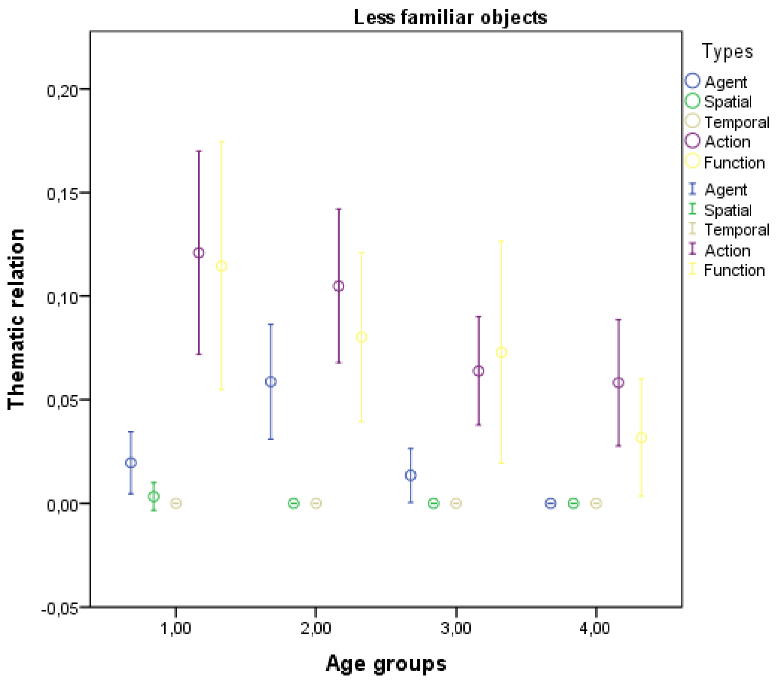
A further analysis with the same model was conducted on the last categorization level, the superordinate one. Specifically, the interaction among its two subcategories, function elements and superordinate nouns, the age and the object familiarity was investigated. The main effect of the two subcategories of superordinate categorization was significant with a Wald Chi-Square 69.97, df 1, $p < .001$, as was the main effect of the level of object familiarity, Wald Chi-Square 3.66, df 1, $p = .056$. The main effect of the age was not significant, with a Wald Chi-Square 5.39, df 3, $p < .145$. The interaction between the age and the two kinds of superordinate subcategories was significant, Wald Chi-Square 12.25, df 3, $p = .007$, as well as that among the age, the level of objects' familiarity and the two kinds of superordinate subcategories, Wald Chi-Square 21.88, df 5, $p = .001$; the interaction among the level of object familiarity and the two kinds of superordinate subcategories was not significant with a Wald Chi-Square 1.31, df 1, $p = .251$. Generally, regarding to less familiar objects, the manifestation of both function elements and superordinate nouns slightly decreases with increasing age. While, concerning objects with higher familiarity, the elicitation of function elements decreases with increasing age, but it remains higher compared to superordinate nouns.

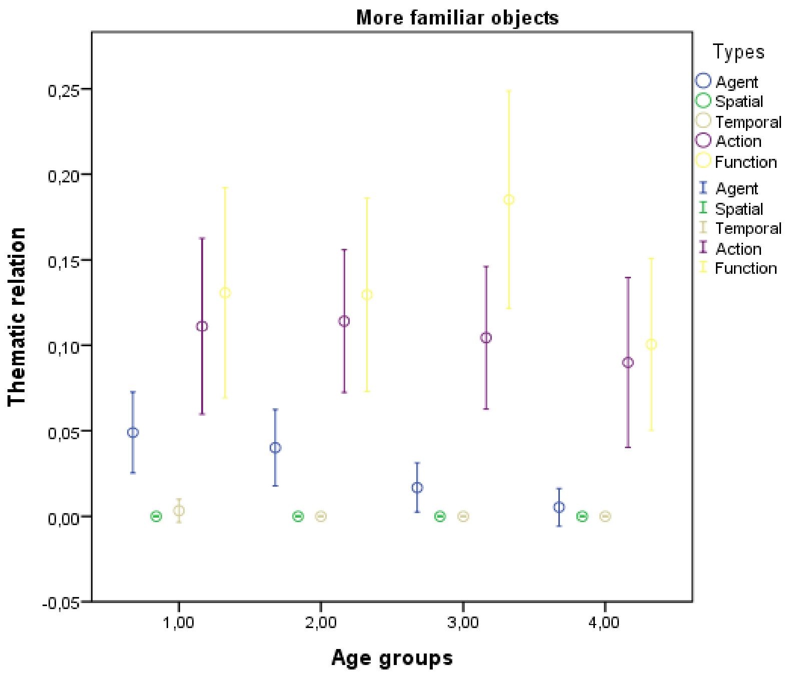
Figure 3. Graphs of the interaction among superordinate categorization subcategories (function elements and superordinate nouns), age and the object familiarity (top panel: high familiarity; bottom panel: low familiarity)



With regard to the subcategories of thematic conceptual relation of object concepts, checked with the age and the level of objects' familiarity, the main effect of the thematic relation types was significant with a Wald Chi-Square 128.07, df 2, $p < .001$, as was the interaction between the thematic relation types and the age variable, Wald Chi-Square 46.83, df 9, $p < .001$, and the interaction between the level of object's familiarity and the types of thematic conceptual relation, Wald Chi-Square 16.06, df 3, $p = .001$. The interaction among all variables was not significant with Wald Chi-Square 11.76, df 9, p .227. Overall, the most adopted thematic relations were agent, action, and function. Specifically, agent relation is most frequent during more familiar objects' descriptions, and its use decreases with increasing age. Action and function relations, instead, remain the preferred across all ages and object familiarity level.

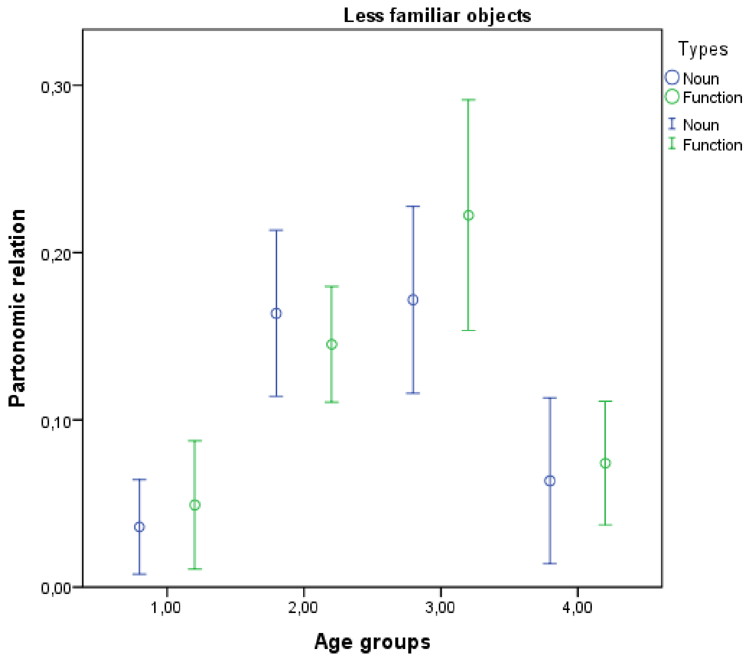
Figure 4. Graphs of the interaction among subcategories of thematic conceptual relation of object concepts, age, and the level of objects' familiarity (top panel: high familiarity; bottom panel: low familiarity)

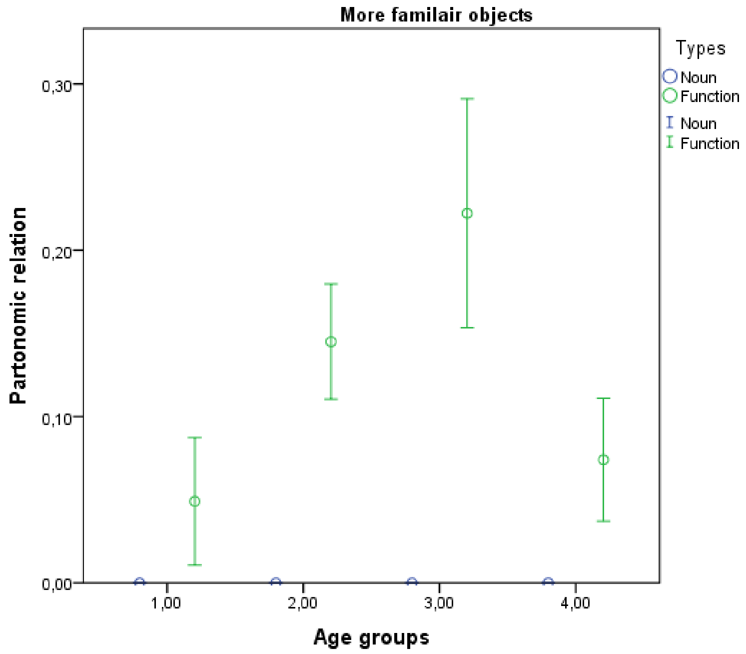




The main effect of the types of partonomic conceptual relation was significant, with a Wald Chi-Square 43.70, df 1, $p < .001$, as was the interaction between the age and object familiarity variables, Wald Chi-Square 43.21, df 6, $p < .001$, the interaction between the level of objects' familiarity and the types of partonomic relation, Wald Chi-Square 90.10, df 1, $p < .001$, and the interaction among the age, the level of objects' familiarity and the types of partonomic relation, Wald Chi-Square 30.85, df 3, $p < .001$. In particular, function-related parts are produced irrespective of the object familiarity level, especially by pre-adolescents. The mere elicitation of parts' names, instead, is more frequent but not dominant in less familiar objects' description.

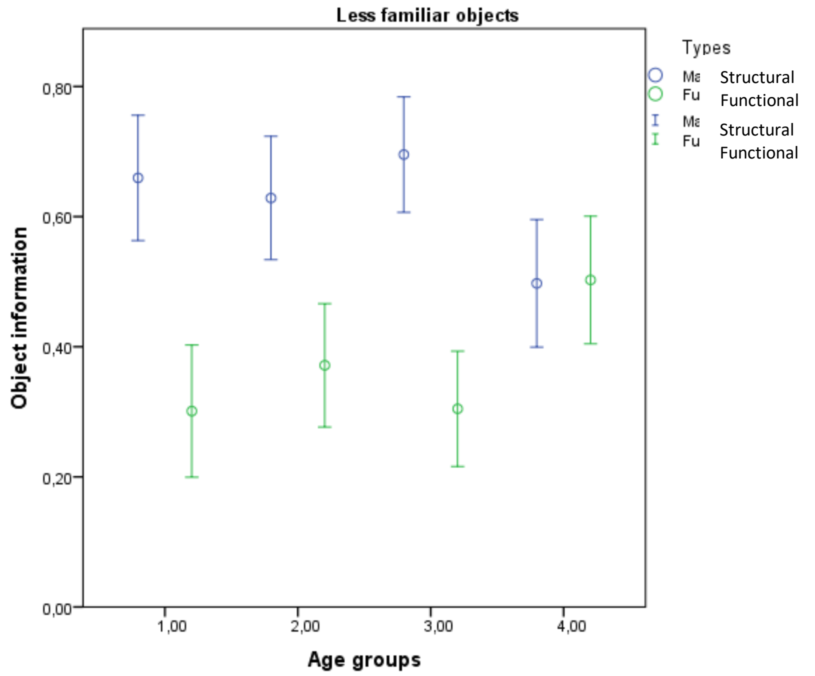
Figure 5. Graphs of the interaction among partonomic conceptual relationships, age and object familiarity, (top panel: high familiarity; bottom panel: low familiarity)

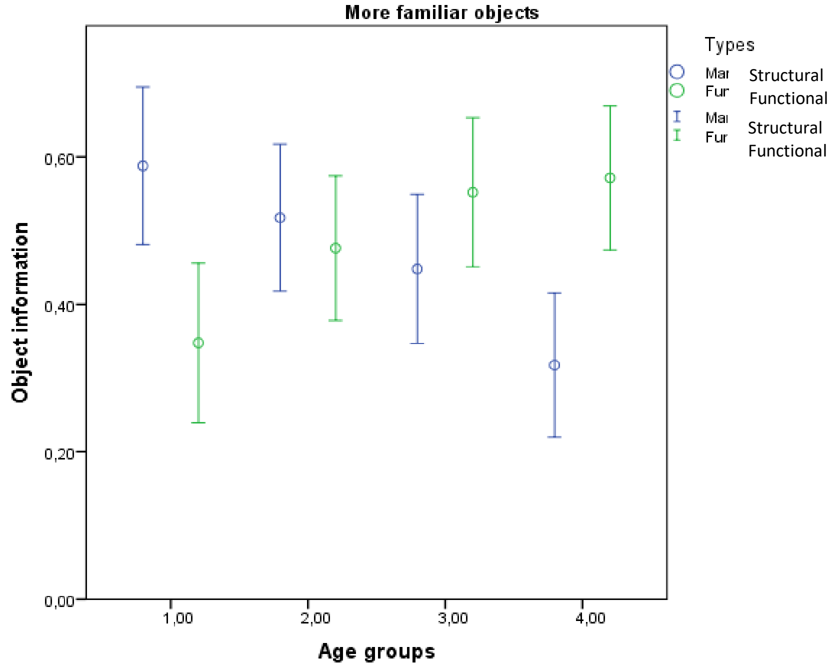




As for the types of object information in concept categorization, checked with the age of an individual and the level of objects' familiarity, the main effect of the types of objects information was significant with Wald Chi-Square= 4,00, df 1, p= .045; the main effect of the age with Wald Chi-Square= 7,05, df 3, p= .070; the main effect of the level of objects' familiarity with Wald Chi-Square= 1,50, df 1, p= .220. The interaction between the age and the types of object information was significant with Wald Chi-Square= 10,42, df 3, p= .015, as was the interaction between the level of objects' familiarity and the types of objects information, Wald Chi-Square= 36,67, df 1, p= < .001, and the 3-way interaction among the age, the level of objects' familiarity and the kinds of object information, Wald Chi-Square 25.51, df 6, p < .001. Figure 6 illustrates the effect of this interaction: generally, structural properties decrease with increasing age, and they occur more frequently in less familiar objects description. More familiar objects mostly elicit functional knowledge, and their incidence increases with increasing age.

Figure 6. Graphs of the interaction among object information (structural vs. functional), age and object familiarity, (top panel: high familiarity; bottom panel: low familiarity)





General discussion

In this study, new findings useful to understand better how the categorization of object concepts is organized were presented. Some of these are in line with previous research; others add interesting pieces to the knowledge system's big puzzle. The study aimed to investigate the kind of knowledge elicited while manipulating less and more familiar objects. Specifically, the interest was to determine whether the different degrees of object familiarity affect the conceptual level at which objects are categorized (subordinate, basic, superordinate), the conceptual relations elicited by objects (thematic, taxonomic, partonomic), and the role of structural and function information. In the study, participants underwent a session of object manipulation followed by two linguistic tasks (naming and free description). Participants included two groups of children (3-5 and 6-9 years of age), a group of pre-adolescents (10-13 years of age), and adults.

Findings provide insights into how the process of category building occurs. Two views concerning category construction contend the camp in literature: according to the first, children acquire first basic-level categories, followed by the superordinate and then by the subordinate ones (Rosch et al., 1976; Markman & Callanan, 1983; Mervis & Crisafi, 1982); the second view proposes instead that children first acquire global, superordinate categories, then they differentiate them into the basic and subordinate ones (Mandler & Bauer, 1988; Mandler, 1992a; 1992b; 1993; Mandler & McDonough, 1993; Mandler, 2008; Bornstein & Arterberry, 2010; Shylaja & Manjula, 2016). Here this latter view can be supported since the youngest age group consistently used superordinate categories. This finding suggests that, generally, unusual instances lead people to categorize them with generic properties and concepts that include more common things, e.g., container or tool. At the same time, they tend to name an object at a basic and subordinate level when they are more confident, e.g., bottle, fork clothespin.

The finding that superordinate categories were more frequent for less familiar objects might seem obvious. However, the fact that the production of superordinate categories and functional elements varied across age groups is all but trivial. Interestingly, regarding less familiar objects, the manifestation of both function elements and superordinate nouns slightly decreased with increasing age. In highly familiar objects, instead, the production of functional relations decreased with increasing age, but it remained more elevated compared to superordinate nouns. Overall, this suggests that people, at any age, prefer to categorize objects, known or unknown, by focusing and emphasizing their functional characteristics, rather than generalizing with a superordinate noun like tool.

The role of object familiarity also influences how object concepts connect. In this study, thematic, partonomic, and taxonomic relations were examined. Results confirmed that children use more frequently thematic than taxonomic relations (see Borghi & Caramelli, 2003, for a similar result). They also confirmed that adults broadly prefer taxonomic than thematic relations, as shown by Tare & Gelman (2010) in a sorting study. However, they revealed that not only children but also pre-adolescents produce more thematic than taxonomic relations. According to several authors, a thematic-to-taxonomic shift characterizes childhood (Markman 1981; 1989; Carey, 1985; Jones & Smith, 1993; Sheya & Smith, 2006; see for a different view Lin & Murphy, 2001). This shift also occurred in this study, but later, in the transition from preadolescence to adulthood. Among less familiar objects, partonomic and taxonomic relations were the most frequent in all age groups. This confirms findings on the relevance of taxonomic relations (Bauer & Mandler, 1989; Osborne & Calhoun, 1998) and results on the importance of structural and functional information concerning object parts in categorizing unknown objects (Tversky, 1989).

Regarding the findings concerning thematic and partonomic conceptual relations, as illustrated above, the most frequent thematic relations were the agent, the action, and the functional ones. Interestingly, agent relations were most frequent in the description of more familiar objects by younger participants. This result suggests that children, more than adults, heavily rely on their own experience in categorizing well-known concepts – they refer to people who act with them through action on objects and likely re-enact internal states linked to those situations (Barsalou, 2008; 2018). The fact that action and function relations remained preferred across all developmental stages for both less and more familiar objects suggests that manipulable objects always evoke possible actions and interactions.

As to partonomic relations, they were very frequent, likely because of the choice to propose objects that can be manipulated. A distinction between the parts merely expressed in their name (e.g., “there is a stick and two cotton balls”) and the parts characterized by functional elements (e.g., “the handles rise and fall”) was operated. During the free description, all age groups, especially pre-adolescents, produced more functional parts than part names independently from the object's familiarity. Partonomic names with no reference to part function were more frequent in less familiar objects’ descriptions than in more known ones. The importance of partonomic relations is interesting, also because the studies focusing on partonomic relations are scarce (for an exception, see Tversky, 1989).

The latest findings specifically refer to the role that object familiarity plays in determining the use of either structural and functional properties. In line with the hypotheses, it was found that the elicitation of structural properties is typical of younger participants (for similar results see Collette et al., 2016), who are not yet acquainted with some object functions. Importantly, children mostly chose to describe structural features when objects were less known. When objects were very familiar, then structural features' prominence decreased with increasing age; this tendency started as early as six years, and it was more evident in preadolescence. In contrast, and as expected, adults were less bounded to structural information during known objects' descriptions. At the same time, they showed no difference in providing structural and functional properties with non-familiar objects. Preadolescents are particularly interesting because, to the best of our knowledge, the role of conceptual information in this age group has not yet been extensively investigated. Specifically, the group of preadolescents, as the two groups of children, most frequently used structural properties in describing less familiar items. Whereas they decreased the use of structural features and increased that of function knowledge when they described known objects.

In conclusion, these findings confirm some important aspect of developmental literature on concept categorization, but also provide interesting insights on affordances linked to the cognitive process of language supporting the perspective of a situated cognition according to which sensorimotor and cognitive processes cannot be separated. It was argued that the level of object concept categorization, the conceptual relationship and the perception of object affordances can be affected by the age and the degree of object familiarity.

CONCLUSIONS AND FUTURE PERSPECTIVES

The main aim of this dissertation was to investigate how actions and concepts related to familiar and non-familiar objects may vary across development.

The point of departure was the concept of affordance and how it has been extensively considered within the Embodied and Grounded Cognition perspective. Moreover, the focus was centred on the different types of affordances that may be perceived by our sensorimotor system, paying particular attention on the structural and functional ones (Chapter 1). The link between affordances and a specific cognitive process that it is widely studied as linked to the sensory motor experiences, i.e., the language, was the second starting point. In this regard, some of the most influential theories of conceptual knowledge were described and the way object concepts are categorized especially from a developmental point of view, was examined (Chapter 2).

By reviewing the literature reported in the first two chapters, it was noticed the lack of experimental investigations with children and preadolescents on the activation of structural and functional affordances during object manipulation and linguistic process. Therefore, the first motivation of this dissertation was to explore this aspect.

The novelty of this investigation was based on the type of stimuli used: familiar and non-familiar objects. Not all studies make use of known objects; other studies prefer the selection of non-familiar stimuli, i.e., stimuli not known by participants who participate in the experiments. Non-familiar stimuli are employed mainly in studies on children, e.g., to test how they acquire new categories and new words and in studies on adults to be certain that no previous knowledge influences their performance.

In planning the experimental designs of the research, it has been realized that a collection of both non-familiar and familiar everyday objects, classified by individuals of different ages, is missing in literature. In this regard, the creation of the Familiar and Non-Familair Stimuli (FANS) Database, namely a set of everyday objects classified by Italian pre-schoolers, schoolers, and adults, was the second major novelty of this dissertation (Chapter 3). This instrument may be useful for researchers to verify how object knowledge is modulated by age and frequency of use, and select the appropriate stimuli for their studies with participants of different ages. The most interesting results of this first study demonstrated that age has an important impact on objects' familiarity and frequency of use. In particular, it was found that as age increases, the level of familiarity and frequency of personal use also rises, reaching a stability during the adulthood. Second, data allowed to classify objects into three categories, high, medium, and low in familiarity, frequency of personal use, and frequency of observed use for three different developmental stages. Then, a less analytical analysis allowed to test the level of awareness and intuition of participants. Findings revealed a higher level of awareness and intuition in older participants and a lower one in younger children, confirmed by the frequent use of alternative answers in naming and function questions. Finally, results comparing familiarity with frequency of personal use and use seen by others showed that, generally, non-familiar objects are less personally used and more often observed when used by others. Curiously, in pre-schoolers, more familiar objects are not always known because these are personally used, but often because they were seen to be used by others. Overall, this study showed that the age modulates affordance perception and object knowledge. In particular, the judgment of familiarity of non-familiar objects changes from childhood to adulthood: while children rely mainly on other people's action and/or their creativity and intuitions, adults refer to previous experiences with objects endowed with similar affordances.

In order to investigate how factors such as sociocultural dynamics may affect the perception of objects, data for familiarity, naming, function, using and frequency of use for the same objects used to create the Familiar And Non-Familiar Stimuli Database, were collected for Dutch and Croatian populations, children and adults (Chapter 4). Results demonstrated that culture has an important impact on object perception. Specifically, regardless the age, the major differences have been found with regard to the frequency of use of objects. In addition, as for Italian data, objects were classified into three levels of familiarity and frequency of use, permitting researchers of Croatian and Dutch populations to use these stimuli in their studies. Overall, the findings of this study may provide useful information for researchers who intend to study familiar and non-familiar objects and their variations in familiarity and frequency of use across ages (from preschoolers to adults) and populations (Italian, Croatian and Dutch). Importantly, these data highlighted the importance of identifying stimuli that are appropriate not only for the goals of a study, but also for the combination of cultural and age variables.

The results obtained in Chapter 3 were crucial to design the main studies of this dissertation (Chapter 5 and Chapter 6). Specifically, the study in Chapter 5 aimed at verifying whether children, preadolescents and adults are affected by the different degrees of object familiarity in choosing structural, functional, and alternative grasp responses when interacting with objects. The general assumptions viewed children more creative and less bounded to functional fixedness than adults when interacting with objects.

Results revealed that, as for more familiar object interaction, participants from the 6 year of age to adulthood tend to prefer structural grasps, although the discrepancy between structural and functional responses in preadolescents and adults is very little. Interestingly, children from 3 to 5 years old mostly perform functional responses. As for the alternative grasps, these are mostly adopted by the youngest group. During the manipulation of less familiar objects, adults, preadolescents and the second group of children mostly adopt structural grasps. Crucially, alternative grasps are strongly dominant in the first age group. Overall, the innovative finding of this study concerns the performance of the youngest group of children. Surprisingly, this group compared to older children, preadolescents and adults is mostly responsive to functional information during more familiar object manipulation, adding an important insight to the literature of affordances from a developmental point of view. Another interesting result refers to the alternative grasps, particularly dominant in the youngest children. This finding is especially important for the phenomenon of functional fixedness. Specifically, the fact that the first group of children mostly adopt alternative grasps during less familiar object manipulation may be justified by the lack of function knowledge of the objects. However, although to a lesser extent, the youngest children also use alternative responses during more familiar object manipulation, suggesting that the phenomenon is not totally linked to a lack of object knowledge. Rather to a low functional fixedness and a high creativity. In sum, the results of this study suggest the important role of experience and of age in responding to objects' affordances and to objects' function.

The last study aimed at investigating how children (3-5 and 6-9 years old), preadolescents, and adults categorize more familiar and less familiar objects. Specifically, the linguistic production of participants was coded in terms of object categorization level, i.e., basic vs. subordinate vs. superordinate, conceptual relations, i.e., thematic vs. partonomic vs. taxonomic, and object information types, i.e., structural vs. function knowledge. As for the categorization level, results showed that the youngest group consistently use superordinate categories, supporting the more recent findings in literature. In addition, they suggest that, generally, unusual instances lead children to categorize them with generic concepts, and that they tend to prefer other categorization level when they are more confident. Results also demonstrated that the role of object familiarity also influences how object concepts connect. Specifically, it has been found that children use more frequently thematic than taxonomic relations during more familiar object interaction and that adults broadly prefer taxonomic than thematic relations, confirming some of the most dominant evidence in developmental research. According to several authors, a thematic-to-taxonomic shift characterizes childhood. This shift also occurs in this study, but later, in the transition from preadolescence to adulthood. Among less familiar objects, partonomic and taxonomic relations were the most frequent in all age groups. This confirmed the importance of structural and functional information concerning object parts. The latest findings of this study refer to the role that object familiarity plays in determining the use of either structural and functional properties. In line with the hypotheses, the elicitation of structural properties was typical of younger participants who are not yet acquaint with some object functions. Interestingly, children mostly choose to describe structural features when objects are less known. When objects are very familiar, then structural features' prominence decrease with increasing age. In contrast, adults are less bounded to structural information during familiar objects' descriptions. At the same time, they show no difference in providing structural and functional properties with non-familiar objects. Preadolescents are particularly interesting because, to the best of our knowledge, the role of conceptual information in this age group has not yet been investigated. Specifically, the group of preadolescents, as the two groups of children, most frequently use structural properties in describing less familiar items. Whereas they decrease the use of structural features and increase that of function knowledge when they describe known objects. Overall, these findings confirm some important aspects of developmental literature on object concept categorization, but also provide interesting insights on affordances linked to the cognitive process of language, i.e., the aspects that the level of object concept categorization, the conceptual relationship and the perception of object affordances can be affected by the age and the degree of object familiarity.

In conclusion, this dissertation provides further evidence in support of the literature on affordances and on the link between affordances and the cognitive process of language from a developmental point of view. This evidence supports the perspective of a situated cognition and emphasize the crucial role of human experience. Last, but not less important, it was created and presented the FANS Database, an instrument useful to plan experimental designs in several fields of cognitive science.

Regarding future perspectives, first it will be crucial to increase the number of stimuli and the sample of the FANS Database to meet the needs of as many researchers as possible. Second, it would be useful to investigate the difference in familiarity between visual and manipulated stimuli to understand the incidence of action on object knowledge. Then, further explorations on the variability of responses in children will be needed to better understand whether it depends on their creativity, on their less rich world experience, or a combination of both. Finally, implications in educational field would be interesting to discuss since the embodied cognition perspective is starting to represent a powerful approach also for teaching and learning processes. As this dissertation proves, the body is a potent tool to understand the environment and guide cognitive processes.

BIBLIOGRAPHY

Adlington, R. L., Laws, K. R., Gale, T. M. (2008). The Hatfield Image Test (HIT): A new picture test and norms for experimental and clinical use. J*ournal of Clinical and Experimental Neuropsychology*. https://doi.org/10.1080/13803390802488103

Adams, D. K. (1931). A restatement of the problem of learning. *British Journal of Psychology (General Section)*, 22, 150-178. https://doi.org/10.1111/j.2044-8295.1931.tb00623

Alario, F. X., Ferrand, L. (1999). A set of 400 pictures standardized for French: norms for name agreement, image agreement, familiarity, visual complexity, image variability, and age of acquisition. *Behaviour Research Methods, Instruments, & Computers.* 31(3):531-552. https://doi.org/10.3758/bf03200732

Anelli, F., Nicoletti, R., Bolzani, R., & Borghi, A. M. (2013). Keep away from danger: dangerous objects in dynamic and static situations. *Frontiers in human neuroscience*, 7, 344. https://doi.org/10.3389/fnhum.2013.00344

Anelli, F., Ranzini, M., Nicoletti, R., & Borghi, A. M. (2013). Perceiving object dangerousness: an escape from pain? *Experimental brain research*, 228(4), 457–466. https://doi.org/10.1007/s00221-013-3577-2

Anelli, F., Nicoletti, R., Kalkan, S., Sahin, E., Borghi, A. M. (2012). Human and robotics hands grasping danger. *The 2012 International Joint Conference on Neural Networks (IJCNN)*, Brisbane, QLD, 2012, pp. 1-8, https://doi.org/10.1109/IJCNN.2012.6252590

Ansuini, C., Giosa, L., Turella, L, Altoè, G., Castiello, U. (2008). An object for an action, the same object for other actions: effects on hand shaping. *Experimental Brain Research.* 185(1):111-119. https://doi.org/10.1007/s00221-007-1136-4

Ansuini, C., Santello, M., Massaccesi, S., & Castiello, U. (2006). Effects of end-goal on hand shaping. *Journal of neurophysiology*, 95(4), 2456–2465. https://doi.org/10.1152/jn.01107.2005

Armstrong, S. L., Gleitman, L. R., & Gleitman, H. (1983). What some concepts might not be. *Cognition*, 13(3), 263–308. https://doi.org/10.1016/0010-0277(83)90012-4

Barsalou L. W. (1999). Perceptual symbol systems. *The Behavioral and brain sciences*, 22(4), 577–660. https://doi.org/10.1017/s0140525x99002149

Barsalou L. W. (2008). Grounded cognition. *Annual review of psychology*, 59, 617–645. https://doi.org/10.1146/annurev.psych.59.103006.093639

Barsalou L. W., Dutriaux L., Scheepers C. (2018). Moving beyond the distinction between concrete and abstract concepts. *Phil. Trans. R. Soc*. B3732017014. http://doi.org/10.1098/rstb.2017.0144

Barsalou L.W., Billman D. (1989) Systematicity and Semantic Ambiguity. In: Gorfein D.S. (eds) Resolving Semantic Ambiguity. *Cognitive Science*. Springer, New York, NY. https://doi.org/10.1007/978-1-4612-3596-5_10

Barsalou, L. W. (1987). The instability of graded structure: Implications for the nature of concepts. In U. Neisser (Ed.), Emory symposia in cognition, 1. Concepts and conceptual development: Ecological and intellectual factors in categorization (p. 101–140). Cambridge University Press.

Barsalou, L. W. (1991). Deriving categories to achieve goals. In G. H. Bower (Ed.), The psychology of learning and motivation: Advances in research and theory. The psychology of learning and motivation: Advances in research and theory, Vol. 27 (p. 1–64). Academic Press. https://doi.org/10.1016/S0079-7421(08)60120-6

Barsalou, L. W. (1992). Frames, concepts, and conceptual fields. In A. Lehrer & E. F. Kittay (Eds.), Frames, fields, and contrasts: New essays in semantic and lexical organization (p. 21–74). Lawrence Erlbaum Associates, Inc.

Barsalou, L. W. (1993). Flexibility, structure, and linguistic vagary in concepts: Manifestations of a compositional system of perceptual symbols. In A. F. Collins, S. E. Gathercole, M. A. Conway, & P. E. Morris (Eds.), Theories of memory (p. 29–101). Lawrence Erlbaum Associates, Inc.

Bates, E., Bretherton, I., Snyder, L., Beeghly, M., Shore, C., McNew, S., Carlson, V., Williamson, C., Garrison, A., et al. (1988). From first words to grammar: Individual differences and dissociable mechanisms. Cambridge University Press. https://doi.org/10.1177/014272379001002808

Bauer, P. J., & Mandler, J. M. (1989). Taxonomies and triads: Conceptual organization in one- to two-year-olds. *Cognitive Psychology*, 21(2), 156–184. https://doi.org/10.1016/0010-0285(89)90006-6

Berlyne, D E. (2000). Novelty and curiosity as determinants of exploratory behaviour. *British Journal of Psychology*. General Section; London, etc. Vol. 41, Iss. 1, (Sep 1, 1950): 68. http://doi.wiley.com/10.1111/j.2044-8295.1950.tb00262.x

Berman, S., Friedman, D., Hamberger, M. et al. Developmental picture norms: Relationships between name agreement, familiarity, and visual complexity for child and adult ratings of two sets of line drawings. *Behavior Research Methods, Instruments, & Computers* 21, 371–382 (1989). https://doi.org/10.3758/BF03202800

Bi, Y., Han, Z., Zhong, S., Ma, Y., Gong, G., Huang, R., Song, L., Fang, Y., He, Y., & Caramazza, A. (2015). The white matter structural network underlying human tool use and tool understanding. *The Journal of neuroscience: the official journal of the Society for Neuroscience*, 35(17), 6822–6835. https://doi.org/10.1523/JNEUROSCI.370914.2015

Bidet-Ildei, C., Beauprez, S. A., Boucard, G. (2020). The link between language and action in aging. *Archives of Gerontology and Geriatrics*, 90, 104099. https://doi.org/10.1016/j.archger.2020.104099

Biederman, I. (1987). Recognition-by-components: A theory of human image understanding. *Psychological Review*, 94(2), 115–147. https://doi.org/10.1037/0033-295X.94.2.115

Binkofski, F., & Buxbaum, L. J. (2013). Two action systems in the human brain. *Brain and language*, 127(2), 222–229. https://doi.org/10.1016/j.bandl.2012.07.007

Binkofski, F., Dohle, C., Posse, S., Stephan, K. M., Hefter, H., Seitz, R. J., & Freund, H. J. (1998). Human anterior intraparietal area subserves prehension: a combined lesion and functional MRI activation study. *Neurology*, 50(5), 1253–1259. https://doi.org/10.1212/wnl.50.5.1253

Booth, A. E., & Waxman, S. R. (2002). Word learning is 'smart': Evidence that conceptual information affects preschoolers' extension of novel words. *Cognition*, 84(1), B11–B22. https://doi.org/10.1016/S0010-0277(02)00015-X

Borghi, A. M. (2020). A Future of Words: Language and the Challenge of Abstract Concepts. *Journal of Cognition*, 3(1): X, pp. 1–18. https://doi.org/10.5334/joc.134

Borghi, A. M., & Barsalou, L. (2019). Perspective in the conceptualization of categories. *Psychological research*, 10.1007/s00426-019-01269-0. Advance online publication. https://doi.org/10.1007/s00426-019-01269-0

Borghi, A. M., & Riggio, L. (2015). Stable and variable affordances are both automatic and flexible. *Frontiers in human neuroscience*, 9, 351. https://doi.org/10.3389/fnhum.2015.00351

Borghi, A. M., Flumini, A., Natraj, N., & Wheaton, L. A. (2012). One hand, two objects: emergence of affordance in contexts. *Brain and cognition*, 80(1), 64–73. https://doi.org/10.1016/j.bandc.2012.04.007

Borghi A. M., Nicoletti, R. (2012). Movimento e azione. In Cubelli, R., Job, R., I processi cognitivi. Roma: Carocci. pp.121-144.

Borghi, A. M., Flumini, A., Cimatti, F., Marocco, D., & Scorolli, C. (2011). Manipulating objects and telling words: A study on concrete and abstract words acquisition. *Frontiers in Psychology*, 2, Article 15. https://doi.org/10.3389/fpsyg.2011.00015

Borghi A.M.; Gianelli C.; Lugli L. (2011). La dimensione sociale delle affordance: Affordance tra io e altri., «Sistemi Intelligenti», 23, pp. 291-30. Il Mulino.

Borghi, A. M., & Riggio, L. (2009). Sentence comprehension and simulation of object temporary, canonical and stable affordances. *Brain research*, 1253, 117–128. https://doi.org/10.1016/j.brainres.2008.11.064

Borghi, A. M. (2007). Object concepts and embodiment: Why sensorimotor and cognitive processes cannot be separated. La nuova critica, 15(4), 447-472.

Borghi, A. (2005). Object Concepts and Action. In D. Pecher & R. Zwaan (Eds.), Grounding Cognition: The Role of Perception and Action in Memory, Language, and Thinking (pp. 8-34). Cambridge University Press. https://doi.org/10.1017/CBO9780511499968.002

Borghi, A. M., Caramelli, N. (2003). Situation bounded conceptual organization in children: from action to spatial relations. *Cognitive development*, 18, 49-60. https://doi.org/10.1016/S0885-2014(02)00161-2

Borghi, A.M. (2002). Concetti e azione. In Borghi, A.M. & Iachini, T. (eds.). Scienze della mente. Bologna: Il Mulino, pp. 203-222.

Borghi, A. M. (1997). L'organizzazione della conoscenza. Aspetti e problemi. Pitagora Editore, Bologna. ISBN: 8837108923

Bornstein M. H. (1984). A descriptive taxonomy of psychological categories used by infants. In: Sophian C., editor. Origins of cognitive skills. Hillsdale, NJ: Erlbaum. pp. 313–338.

Bornstein, M. H., & Arterberry, M. E. (2010). The development of object categorization in young children: hierarchical inclusiveness, age, perceptual attribute, and group versus individual analyses. *Developmental psychology*, 46(2), 350–365. https://doi.org/10.1037/a0018411

Bradley, M. M., & Lang, P. J. (2000). Affective reactions to acoustic stimuli. *Psychophysiology*, 37(2), 204–215. https://doi.org/10.1111/1469-8986.3720204

Brodeur, M. B., Dionne-Dostie, E., Montreuil, T., Lepage, M., (2010). The Bank of Standardized Stimuli (BOSS), a New Set of 480 Normative Photos of Objects to be used as Visual Stimuli in Cognitive Research. *PLoS ONE* 5(5): e10773. https://doi.org/10.1371/journal.pone.0010773

Brodeur, M. B., Guérard, K., Bouras, M. (2014). Bank of Standardized Stimuli (BOSS) Phase II: 930 New Normative Photos. *PLoS ONE* 9(9): e106953. https://doi.org/10.1371/journal.pone.0106953.

Brooks, L. R. (1987). Decentralized control of categorization: The role of prior processing episodes. In U. Neisser (Ed.), Emory symposia in cognition, 1. Concepts and conceptual development: Ecological and intellectual factors in categorization (p. 141–174). Cambridge University Press.

Brown, J. F. (1929). The methods of Kurt Lewin in the psychology of action and affection. *Psychological Review*, 36(3), 200–221. https://doi.org/10.1037/h0076029

Bub, D.N., Masson, M.E.J., and Cree, G.S. (2008). Evocation of functional and volumetric gestural knowledge by objects and words. *Cognition.* 106(1), 27-58. https://doi.org/10.1016/j.cognition.2006.12.010

Buccino, G., Sato, M., Cattaneo, L., Rodà, F., & Riggio, L. (2009). Broken affordances, broken objects: a TMS study. *Neuropsychologia*, 47(14), 3074–3078. https://doi.org/10.1016/j.neuropsychologia.2009.07.003

Busing, F. M. R. A., Commandeur, J. J. F., Heiser, W. J. Bandilla, W. & Faulbaum, F. (1997). PROXSCAL: A Multidimensional Scaling Program for Individual Differences Scaling with Constraints. In W. Bandilla & F. Faulbaum (Eds.)

Advances in statistical software (Vol. 6, pp. 67-73). Stuttgart, Germany: Lucius& Lucius.

Buxbaum L. J. (2017). Learning, remembering, and predicting how to use tools: Distributed neurocognitive mechanisms: Comment on Osiurak and Badets (2016). *Psychological review*, 124(3), 346–360. https://doi.org/10.1037/rev0000051

Buxbaum, L. J., & Kalénine, S. (2010). Action knowledge, visuomotor activation, and embodiment in the two action systems. *Annals of the New York Academy of Sciences*, 1191, 201–218. https://doi.org/10.1111/j.1749-6632.2010.05447.x

Buxbaum, L. J., Kyle, K. M., Tang, K., & Detre, J. A. (2006). Neural substrates of knowledge of hand postures for object grasping and functional object use: evidence from fMRI. *Brain research*, 1117(1), 175–185. https://doi.org/10.1016/j.brainres.2006.08.010

Buxbaum, L. J., Sirigu, A., Schwartz, M. F., & Klatzky, R. (2003). Cognitive representations of hand posture in ideomotor apraxia. *Neuropsychologia*, 41(8), 1091–1113. https://doi.org/10.1016/s0028-3932(02)00314-7

Buxbaum L. J. (2001). Ideomotor apraxia: a call to action. *Neurocase*, 7(6), 445–458. https://doi.org/10.1093/neucas/7.6.445

Buxbaum, L. J., Veramonti, T., & Schwartz, M. F. (2000). Function and manipulation tool knowledge in apraxia: Knowing 'what for' but not 'how.' *Neurocase*, 6(2), 83–97. https://doi.org/10.1093/neucas/6.2.83

Cannard, C., Blaye, A., Scheuner, N., & Bonthoux, F. (2005). Picture naming in 3- to 8-year-old French children: methodological considerations for name agreement. *Behavior research methods*, 37(3), 417–425. https://doi.org/10.3758/bf03192710

Cantor, N., Mischel, W. (1979). Prototypes in Person Perception. In Advances in Experimental Social Psychology. Editor: Leonard Berkowitz. Academic Press, Vol. 12, Pages 3-52, ISSN 0065-2601, ISBN 9780120152124. https://doi.org/10.1016/S00652601(08)60258-0

Capitani, E., Laiacona, M., & Barbarotto, R. (1999). Gender affects word retrieval of certain categories in semantic fluency tasks. *Cortex; a journal devoted to the study of the nervous system and behavior*, 35(2), 273–278. https://doi.org/10.1016/s0010-9452(08)70800-1

Carey, S. (1985). Conceptual change in childhood. Cambridge, Mass: MIT Press

Caruana, F. and Borghi, A. M. (2016). Il cervello in azione. Il Mulino, Bologna. ISBN: 9788815263636

Caruana, F., Borghi, A. M. (2013). Embodied cognition: una nuova psicologia. https://dx.doi.org/10.1421/73973

Chaffin, R. (1992). The concept of a semantic relation. In A. Lehrer & E. Kittay (Eds.), Frames, fields, and contrasts: New essays in semantic and lexical organization (pp. 253–388). Hillsdale, NJ: Erlbaum.

Chaffin, R., Herrmann, D. J. & Winston, M. (1988) An empirical taxonomy of part-whole relations: Effects of part-whole relation type on relation identification, *Language and Cognitive Processes*, 3:1, 17-48. https://doi.org/10.1080/01690968808402080

Citron, F. M., Gray, M. A., Critchley, H. D., Weekes, B. S., & Ferstl, E. C. (2014). Emotional valence and arousal affect reading in an interactive way: neuroimaging evidence for an approach-withdrawal framework. *Neuropsychologia*, 56(100), 79–89. https://doi.org/10.1016/j.neuropsychologia.2014.01.002

Clark, A., & Chalmers, D. (1998). The Extended Mind. Analysis, 58(1), 7-19. Retrieved November 4, 2020, from http://www.jstor.org/stable/3328150

Collette, C., Bonnotte, I., Jacquemont, C., Kalénine, S., Bartolo, A. (2016) The development of object function and manipulation knowledge. Evidence from a Semantic Priming Study. *Frontiers in Psychology*, 7, 1239. https://doi.org/10.3389/fpsyg.2016.01239

Cycowicz, Y. M., Friedman, D., Rothstein, M., & Snodgrass, J. G. (1997). Picture naming by young children: norms for name agreement, familiarity, and visual complexity. *Journal of experimental child psychology*, 65(2), 171-237. https://doi.org/10.1006/jecp.1996.2356

Defeyter, M. A., & German, T. P. (2003). Acquiring an understanding of design: evidence from children's insight problem solving. *Cognition*, 89(2), 133–155. https://doi.org/10.1016/s0010-0277(03)00098-2

Duñabeitia, J. A., Crepaldi, D., Meyer, A. S., New, B., Pliatsikas, C., Smolka, E., & Brysbaert, M. (2018). MultiPic: A standardized set of 750 drawings with norms for six European languages. *Quarterly journal of experimental psychology* (2006), 71(4), 808–816. https://doi.org/10.1080/17470218.2017.1310261

Duncker, K. (1945). On problem-solving. *Psychological Monographs*, 58, i-113. https://doi.org/10.1037/h0093599

Elhacham, E., Ben-Uri, L., Grozovski, J., M. Bar-On, Y., Milo, R. (2020). Global human-made mass exceeds all living biomass. *Nature* 588, 442–444.

https://doi.org/10.1038/s41586-020-3010-5

Elliott, R., Zahn, R., Deakin, J. F., & Anderson, I. M. (2011). Affective cognition and its disruption in mood disorders. *Neuropsychopharmacology: official publication of the American College of Neuropsychopharmacology*, 36(1), 153–182. https://doi.org/10.1038/npp.2010.77

Ellis, R., & Tucker, M. (2000). Micro-affordance: the potentiation of components of action by seen objects. *British journal of psychology* (London, England: 1953), 91 (Pt 4), 451–471. https://doi.org/10.1348/000712600161934

Engel, A. K., Maye, A., Kurthen, M., & König, P. (2013). Where's the action? The pragmatic turn in cognitive science. *Trends in cognitive sciences*, 17(5), 202–209. https://doi.org/10.1016/j.tics.2013.03.006

Estes, Z., Golonka, S., & Jones, L. L. (2011). Thematic thinking: The apprehension and consequences of thematic relations. In B. H. Ross (Ed.), The psychology of learning and motivation: Vol. 54. *The psychology of learning and motivation: Advances in research and theory* (p. 249–294). Elsevier Academic Press.

Ferri, F., Stoianov, I. P., Gianelli, C., D'Amico, L., Borghi, A. M., & Gallese, V. (2010). When action meets emotions: how facial displays of emotion influence goal-related behavior. *PloS one*, 5(10), e13126. https://doi.org/10.1371/journal.pone.0013126

Ferri, F., Campione, G. C., Dalla Volta, R., Gianelli, C., & Gentilucci, M. (2011). Social requests and social affordances: How they affect the kinematics of motor sequences during interactions between conspecifics. *PLoS ONE*, 6(1), Article e15855. https://doi.org/10.1371/journal.pone.0015855

Fischer M. H. (2012). A hierarchical view of grounded, embodied, and situated numerical cognition. *Cognitive processing*, 13 Suppl. 1, S161–S164. https://doi.org/10.1007/s10339-012-0477-5

Foglia, L., & Wilson, R. A. (2013). Embodied cognition. Wiley interdisciplinary reviews. *Cognitive science*, 4(3), 319–325. https://doi.org/10.1002/wcs.1226

Fodor, J. A. (1975). The Language of Thought. Harvard University Press. ISBN(s) 0674510305 9780674510302. https://doi.otg/10.2307/2184356

Gallese V. (2008). Mirror neurons and the social nature of language: the neural exploitation hypothesis. *Social neuroscience*, 3(3-4), 317–333. https://doi.org/10.1080/17470910701563608

Gallese V. (2007) The Ventro-dorsal Stream: Parieto-premotor Neural Circuits and Their Role in Primate Cognition. In: Mast F., Jäncke L. (eds) Spatial Processing in Navigation, Imagery and Perception. Springer, Boston, MA. https://doi.org/10.1007/978-0-387-71978-8_17

Gallese, V., & Lakoff, G. (2005). The Brain's concepts: the role of the Sensory-motor system in conceptual knowledge. *Cognitive neuropsychology*, 22(3), 455–479. https://doi.org/10.1080/02643290442000310

Gallese, V., Fadiga, L., Fogassi, L., & Rizzolatti, G. (1996). Action recognition in the premotor cortex. *Brain: a journal of neurology*, 119 (Pt 2), 593–609. https://doi.org/10.1093/brain/119.2.593

Galletti, C., Fattori, P., Gamberini, M., & Kutz, D. F. (2004). The most direct visual pathway to the frontal cortex. *Cortex; a journal devoted to the study of the nervous system and behavior*, 40(1), 216–217.

https://doi.org/10.1016/s0010-9452(08)70956-0

Garcea, F. E., & Mahon, B. Z. (2012). What is in a tool concept? Dissociating manipulation knowledge from function knowledge. *Memory & cognition*, 40(8), 1303–1313. https://doi.org/10.3758/s13421-012-0236-y

Gelman, S. A. (2003). The essential child: Origins of essentialism in everyday thought. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195154061.001.0001

Gelman, S. A., & Bloom, P. (2000). Young children are sensitive to how an object was created when deciding what to name it. *Cognition*, 76(2), 91–103. https://doi.org/10.1016/s0010-0277(00)00071-8

Gelman, S. A., & Coley, J. D. (1990). The importance of knowing a dodo is a bird: Categories and inferences in 2-year-old children. *Developmental Psychology*, 26(5), 796–804. https://doi.org/10.1037/0012-1649.26.5.796

Gelman, S. A., & Markman, E. M. (1987). Young children's inductions from natural kinds: The role of categories and appearances. *Child Development*, 58(6), 1532–1541. https://doi.org/10.2307/1130693

German, T.P., Defeyter, M.A. (2000). Immunity to functional fixedness in young children. *Psychonomic Bulletin & Review* 7, 707–712. https://doi.org/10.3758/BF03213010

Gianelli, C., Scorolli, C., & Borghi, A. M. (2013). Acting in perspective: the role of body and language as social tools. *Psychological research*, 77(1), 40–52. https://doi.org/10.1007/s00426-011-0401-0

Gianelli, C., Lugli, L., Baroni, G., Nicoletti, R., Borghi, A. M. (2011). The object is wonderful or prickly": how different object properties modulate behavior in a joint context. In: Kokinov, B., Karmiloff-Smith, A., Nersessian, N. J. (eds.) European Perspectives on Cognitive Science. New Bulgarian University Press, ISBN 978-954-535-660-5

Gibson, J. J. (1977) The Theory of Affordances. In Shaw, R., & Bransford, J. (Eds.). (1977). Perceiving, acting, and knowing: Toward an ecological psychology. Hillsdale, New Jersey: Lawrence Erlbaum. 67-82. https://doi.org/10.4324/9781315467931

Gibson, J. J. (1979). The ecological Approach to Visual Perception. Boston: Houghton Mifflin.

Glenberg, A. M., & Gallese, V. (2012). Action-based language: a theory of language acquisition, comprehension, and production. *Cortex* 48(7), 905–922. https://doi.org/10.1016/j.cortex.2011.04.010

Goldenberg, G., & Spatt, J. (2009). The neural basis of tool use. *Brain: a journal of neurology*, 132(Pt 6), 1645–1655. https://doi.org/10.1093/brain/awp080

Goldenberg G. (2014). Apraxia - the cognitive side of motor control. *Cortex: a journal devoted to the study of the nervous system and behavior*, 57, 270–274. https://doi.org/10.1016/j.cortex.2013.07.016

Goodman, J. C., McDonough, L., Brown, N. B. (1998). The Role of Semantic Context and Memory in the Acquisition of Novel Nouns. *Child Development*, 69 (5), 1330-1344. https://doi.org/10.1111/j.1467-8624.1998.tb06215.x

Greeno J. G. (1994). Gibson's affordances. *Psychological review*, 101(2), 336–342. https://doi.org/10.1037/0033-295x.101.2.336

Hampton, J. A. (1979). Polymorphous concepts in semantic memory. *Journal of Verbal Learning & Verbal Behavior*, 18(4), 441–461. https://doi.org/10.1016/S0022-5371(79)90246-9

Homa, D., Hout, M. C., Milliken, L., & Milliken, A. M. (2011). Bogus concerns about the false prototype enhancement effect. *Journal of experimental psychology. Learning, memory, and cognition*, 37(2), 368–377. https://doi.org/10.1037/a0021803

Honeck, R.P., Firment, M. (1989). Accessing abstract categories. *Bull. Psychon. Soc*. 27, 206–208. https://doi.org/10.3758/BF03334585

Horoufchin, H., Bzdok, D., Buccino, G., Borghi, A. M. & Binkofski, F. (2018). Action and object words are differentially anchored in the sensory motor system - A perspective on cognitive embodiment. *Scientific Reports.* 8:6583. https://doi.org/10.1038/s41598-018-24475-z

Horst, J. S., & Hout, M. C. (2016). The Novel Object and Unusual Name (NOUN) Database: A collection of novel images for use in experimental research. *Behavior research methods, 48(4), 1393–1409*. https://doi.org/10.3758/s13428-015-0647-3

Horst, J. S., & Samuelson, L. K. (2008). Fast mapping but poor retention by 24-month-old infants. *Infancy*, 13(2), 128–157. https://doi.org/10.1080/15250000701795598

Hummel. J. E. (2000). Where view-based theories break down: The role of structure in human shape perception. In E. Dietrich & A. B. Markman (Eds.). *Cognitive*

Dynamics: Conceptual and representational change in humans and machines. 157-185. Mahwah, NJ: Erlbaum.

Hunnius, S., & Bekkering, H. (2010). The early development of object knowledge: A study of infants' visual anticipations during action observation. *Developmental Psychology*, 46(2), 446–454. https://doi.org/10.1037/a0016543

Jax, S. A., & Buxbaum, L. J. (2010). Response interference between functional and structural actions linked to the same familiar object. *Cognition*, 115(2), 350–355. https://doi.org/10.1016/j.cognition.2010.01.004

Jax, S. A., & Buxbaum, L. J. (2013). Response interference between functional and structural object-related actions is increased in patients with ideomotor apraxia. *Journal of neuropsychology*, 7(1), 12–18. https://doi.org/10.1111/j.1748-6653.2012.02031.x

Jeannerod, M. (1997). Fundamentals of cognitive neuroscience. The cognitive neuroscience of action. Blackwell Publishing.

Jeannerod, M. (1994). The representing brain: Neural correlates of motor intention and imagery. *Behavioral and Brain Sciences*, 17(2), 187–245. https://doi.org/10.1017/S0140525X00034026

Johnson, S. H., & Grafton, S. T. (2003). From 'acting on' to 'acting with': the functional anatomy of object-oriented action schemata. *Progress in brain research*, 142, 127–139. https://doi.org/10.1016/S0079-6123(03)42010-4

Jolicoeur, P., Gluck, M. A., & Kosslyn, S. M. (1984). Pictures and names: Making the connection. *Cognitive Psychology*, 16(2), 243–275. https://doi.org/10.1016/0010-0285(84)90009-4

Jones, S. S. & Smith, L. B. (1993). The place of perception in children's concepts. *Cognitive development*, 8(2), 113-139. https://doi.org/10.1016/0885-2014(93)90008-S

Kalénine, S. (2009). Le rôle de l'action dans l'accès aux concepts d'objets. Apport de la neuropsychologie et des neurosciences cognitives. *Revue de Neuropsychologie*, 1(2), 1-9. https://doi.org/110.3917/rne.012.0150

Kalénine, S., Peyrin, C., Pichat, C., Segebarth, C., Bonthoux, F., & Baciu, M. (2009). The sensory-motor specificity of taxonomic and thematic conceptual relations: a behavioral and fMRI study. *NeuroImage*, 44(3), 1152–1162. https://doi.org/10.1016/j.neuroimage.2008.09.043

Kalénine, S., & Buxbaum, L. J. (2016). Thematic knowledge, artifact concepts, and the left posterior temporal lobe: Where action and object semantics converge. *Cortex; a journal devoted to the study of the nervous system and behavior*, 82, 164–178. https://doi.org/10.1016/j.cortex.2016.06.008

Keil, F. C. (1979). Semantic and conceptual development: an ontological perspective. Cambridge, Mass: Harvard University Press.

Keil, F. C. (1992). Concepts, kinds, and cognitive development. Cambridge, Mass: MIT Press.

Keil, F. C. (1994). The birth and nurturance of concepts by domains: The origins of concepts of living things. In L. A. Hirschfeld & S. A. Gelman (Eds.), Mapping the mind: Domain specificity in cognition and culture (p. 234–254). Cambridge University Press. https://doi.org/10.1017/CBO9780511752902.010

Klatzky, R. L., McCloskey, B., Doherty, S., Pellegrino, J., & Smith, T. (1987). Knowledge about hand shaping and knowledge about objects. *Journal of Motor Behavior*, 19(2), 187–213. https://doi.org/10.1080/00222895.1987.10735407

Koffka, K. (1935). Principles of Gestalt psychology. Harcourt, Brace.

Kremin, H., Akhutina, T., Basso, A., Davidoff, J., De Wilde, M., Kitzing, P., Lorenz, A., Perrier, D., van der Sandt-Koenderman, M., Vendrell, J., Weniger, D., Apt, P., Arabia, C., De Bleser, R., Cohen, H., Corbineau, M., Dolivet, M. C., Hirsh, K., Lehoux, E., Metz-Lutz, M. N., Vish-Brink, E. (2003). A cross-linguistic data bank for oral picture naming in Dutch, English, German, French, Italian, Russian, Spanish, and Swedish (PEDOI). *Brain and cognition*, 53(2), 243–246. https://doi.org/10.1016/s0278-2626(03)00119-2

Lassaline, M. E., Wisniewski, E. J., & Medin, D. L. (1992). Basic levels in artificial and natural categories: Are all basic levels created equal? In B. Burns (Ed.), Precepts concepts, and categories: The representation and processing of information. Advances in psychology, Vol. 93 (pp. 327-378). Amsterdam: North-Holland.

Laws K. R. (1999). Gender affects naming latencies for living and nonliving things: implications for familiarity. *Cortex; a journal devoted to the study of the nervous system and behavior*, 35(5), 729–733. https://doi.org/10.1016/s0010-9452(08)70831-1

Lawson, R., Changa, F., Wills, A. J. (2017). Free classification of large sets of everyday objects is more thematic than taxonomic. *Acta Psychologica*, 172, 26-40. https://doi.org/10.1016/j.actpsy.2016.11.001

Lewin, K. (1938). Will and needs. In W. D. Ellis (Ed.), A source book of Gestalt psychology (p. 283–299). Kegan Paul, Trench, Trubner & Company. https://doi.org/10.1037/11496-024

Lin, E. L., & Murphy, G. L. (2001). Thematic relations in adults' concepts. *Journal of Experimental Psychology: General*, 130(1), 3–28. https://doi.org/10.1037/0096-3445.130.1.3

Lucariello, J., Kyratzis, A., & Nelson, K. (1992). Taxonomic Knowledge: What Kind and When? *Child Development*, 63(4), 978-998. https://doi.org/10.2307/1131248

Mandler, J. M. (1992). How to build a baby: II Conceptual primitives. *Psychological Review*, 99(4), 587–604. https://doi.org/10.1037/0033-295X.99.4.587

Mandler, J. M. (1992). The foundations of conceptual thought in infancy. *Cognitive Development*, 7(3), 273–285. https://doi.org/10.1016/0885-2014(92)90016-K

Mandler, J. M. (1993). On concepts. *Cognitive Development*, 8(2), 141–148. https://doi.org/10.1016/0885-2014(93)90009-T

Mandler, J. M. (2004). A synopsis of The foundations of mind: Origins of conceptual thought (2004). New York: Oxford University Press. Developmental Science, 7(5), 499–505. https://doi.org/10.1111/j.1467-7687.2004.00369.x

Mandler, J. M. (2008). On the birth and growth of concepts. *Philosophical Psychology*, 21(2), 207–230. https://doi.org/10.1080/09515080801980179

Mandler, J. M., & Bauer, P. J. (1988). The cradle of categorization: Is the basic level basic? *Cognitive Development*, 3(3), 247–264. https://doi.org/10.1016/0885-2014(88)900111

Mandler, J. M., & McDonough, L. (1993). Concept formation in infancy. *Cognitive Development*, 8(3), 291–318. https://doi.org/10.1016/S0885-2014(93)80003-C

Mann, H.B. and Whitney, D.R. (1947) On a Test of Whether One of Two Random Variables Is Stochastically Larger than the Other. *Annals of Mathematical Statistics*, 18, 50-60. http://dx.doi.org/10.1214/aoms/1177730491

Marino, B. F., Borghi, A. M., Buccino, G., & Riggio, L. (2017). Chained Activation of the Motor System during Language Understanding. *Frontiers in psychology*, 8, 199. https://doi.org/10.3389/fpsyg.2017.00199

Markman, E. M. (1989). The MIT Press series in learning, development, and conceptual change.Categorization and naming in children: Problems of induction. The MIT Press. https://doi.org/10.1017/S030500090001134X

Markman, E. M., Horton, M. S., & McLanahan, A. G. (1980). Classes and collections: principles of organization in the learning of hierarchical relations. *Cognition*, 8(3), 227–241. https://doi.org/10.1016/0010-0277(80)90006-2

Markman, E.M. (1981). Two different principles of conceptual organization. In M. Lamb & A. Brown (Eds.) Advances in developmental psychology (Vol. 1). Hillsdale, N.J.: Lawrence Erlbaum Associates.

Markman, E.M., & Callanan, M.A. (1983). An analysis of hierarchical classification. In R. Sternberg (Ed.) Advances in the psychology of human intelligence (Vol. 2) (pp. 325-365). Hillsdale, NJ: Erlbaum.

McCloskey, M. E., & Glucksberg, S. (1978). Natural categories: Well defined or fuzzy sets? *Memory & Cognition*, 6(4), 462–472. https://doi.org/10.3758/BF03197480

Medin, D. L., & Schaffer, M. M. (1978). Context theory of classification learning. *Psychological Review*, 85(3), 207–238. https://doi.org/10.1037/0033-295X.85.3.207

Mervis, C. B., & Crisafi, M. A. (1982). Order of acquisition of subordinate-, basic-, and superordinate-level categories. *Child Development*, 53(1), 258–266. https://doi.org/10.2307/1129660

Mervis, C. B., & Mervis, C. A. (1988). Role of adult input in young children's category evolution: I. An observational study. *Journal of Child Language*, 15(2), 257–272. https://doi.org/10.1017/S0305000900012368

Migo, E. M., Montaldi, D., & Mayes, A. R. (2013). A visual object stimulus database with standardized similarity information. *Behavior Research Methods*, 45(2), 344–354. https://doi.org/10.3758/s13428-012-0255-4

Milner A. D. (2017). How do the two visual streams interact with each other? *Experimental brain research*, 235(5), 1297–1308. https://doi.org/10.1007/s00221-017-4917-4

Milner, A. D., & Goodale, M. A. (2008). Two visual systems re-viewed. *Neuropsychologia*, 46(3), 774–785. https://doi.org/10.1016/j.neuropsychologia.2007.10.005

Milner, A.D. & Goodale, M.A. (1995). The Visual Brain in Action. Oxford: Oxford University Press.

Miller, G. A., & Johnson-Laird, P. N. (1976). Language and perception. Belknap Press. https://doi.org/10.1017/S0022226700006010

Miranda, M. C., Pompéia, S., & Bueno, O. F. (2004). Um estudo comparativo das normas de um conjunto de 400 figuras entre crianças brasileiras e americanas [A comparative study of norms for a 400 picture set between Brazilian and American children]. *Revista brasileira de psiquiatria* (Sao Paulo, Brazil: 1999), 26(4), 226–233. https://doi.org/10.1590/S1516-44462004000400005

Mirman, D., Landrigan, J. F., & Britt, A. E. (2017). Taxonomic and thematic semantic systems. *Psychological bulletin*, 143(5), 499–520. https://doi.org/10.1037/bul0000092

Murphy, G. L. (2002). The big book of concepts. MIT Press.

Murphy, G. L., & Medin, D. L. (1985). The role of theories in conceptual coherence. *Psychological Review*, 92(3), 289–316. https://doi.org/10.1037/0033-295X.92.3.289

Murphy, G. L., & Smith, E. E. (1982). Basic-level superiority in picture categorization. *Journal of Verbal Learning & Verbal Behavior*, 21(1), 1–20. https://doi.org/10.1016/S0022-5371(82)90412-1

Murphy, G. L., & Wisniewski, E. J. (1989). Categorizing objects in isolation and in scenes: What a superordinate is good for. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 15(4), 572–586. https://doi.org/10.1037/0278-7393.15.4.572

Nelder, J., & Wedderburn, R. (1972). Generalized Linear Models. *Journal of the Royal Statistical Society*. Series A (General), 135(3), 370-384. https://doi.org/10.2307/2344614

Nicoletti, R., Borghi, A. M. (2007). Il controllo motorio. Il Mulino, Bologna. ISBN: 8815118861

Norman, A. D. (1997). La caffettiera del masochista. Prato: *Giunti Editore*.

O'Regan, J. K., & Noë, A. (2001). A sensorimotor account of vision and visual consciousness. *The Behavioral and brain sciences*, 24(5), 939–1031. https://doi.org/10.1017/s0140525x01000115

Orban, G. A., & Caruana, F. (2014). The neural basis of human tool use. *Frontiers in psychology*, 5, 310. https://doi.org/10.3389/fpsyg.2014.00310

Osborne, J. G. & Calhoun, D. O. (1998). Themes, Taxons, and Trial Types in Children's Matching to Sample: Methodological Considerations. *Journal of Experimental Child Psychology*. 68(1), 35-50. https://doi.org/10.1006/jecp.1997.2420

Osiurak, F., Rossetti, Y., & Badets, A. (2017). What is an affordance? 40 years later. *Neuroscience and biobehavioral reviews*, 77, 403–417.

Osiurak, F., & Badets, A. (2016). Tool use and affordance: Manipulation-based versus reasoning-based approaches. *Psychological review*, 123(5), 534–568. https://doi.org/10.1037/rev0000027

Pecher, D., & Zwaan, R. (2005). Introduction to Grounding Cognition: The Role of Perception and Action in Memory, Language, and Thinking. In D. Pecher & R. Zwaan (Eds.), Grounding Cognition: The Role of Perception and Action in Memory, Language, and Thinking (pp. 1-7). Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511499968.001

Pellicano, A., Iani, C., Borghi, A. M., Rubichi, S., & Nicoletti, R. (2010). Simon-like and functional affordance effects with tools: the effects of object perceptual discrimination and object action state. *Quarterly journal of experimental psychology* (2006), 63(11), 2190–2201. https://doi.org/10.1080/17470218.2010.486903

Pezzulo, G., Barsalou, L. W., Cangelosi, A., Fischer, M. H., McRae, K., & Spivey, M. J. (2013). Computational Grounded Cognition: a new alliance between grounded cognition and computational modeling. *Frontiers in psychology*, 3, 612. https://doi.org/10.3389/fpsyg.2012.00612

Pezzulo, G., Barsalou, L. W., Cangelosi, A., Fischer, M. H., McRae, K., & Spivey, M. J. (2011). The mechanics of embodiment: a dialog on embodiment and computational modeling. *Frontiers in psychology*, 2, 5. https://doi.org/10.3389/fpsyg.2011.00005

Pezzulo, G., Barca, L., Bocconi, A. L., & Borghi, A. M. (2010). When affordances climb into your mind: advantages of motor simulation in a memory task performed by novice and expert rock climbers. *Brain and cognition*, 73(1), 68–73. https://doi.org/10.1016/j.bandc.2010.03.002

Pind, J., Jónsdóttir, H., Tryggvadóttir, H. B., & Jónsson, F. (2000). Icelandic norms for the Snodgrass and Vanderwart (1980) pictures: name and image agreement, familiarity, and age of acquisition. *Scandinavian journal of psychology*, 41(1), 41–48. https://doi.org/10.1111/1467-9450.00169

Pisella, L., Binkofski, F., Lasek, K., Toni, I., & Rossetti, Y. (2006). No double-dissociation between optic ataxia and visual agnosia: multiple sub-streams for multiple visuo-manual integrations. *Neuropsychologia*, 44(13), 2734–2748. https://doi.org/10.1016/j.neuropsychologia.2006.03.027

Plessner, H., Betsch, C., Betsch, T. (2011). Intuition in Judgment and Decision Making. Psychology Press.

Pompeia S., Miranda M. C., Bueno O. F. (2001). A set of 400 pictures standardised for Portuguese: norms for name agreement, familiarity and visual complexity for children and adults. *Arquivos de Neuro-Psiquiatria* 59: 330–337. https://doi.org/10.1590/S0004-282X2001000300004

Pompeia, S., Miranda, M. C., Bueno, O. F. (2003). Brazilian standardized norms for a set of pictures are comparable with those obtained internationally. *Arquivos de Neuro-Psiquiatria.* 61:916-919. https://doi.org/10.1590/s1516-44462004000400005

Pribbenow S. (2002) Meronymic Relationships: From Classical Mereology to Complex Part-Whole Relations. In: Green R., Bean C.A., Myaeng S.H. (eds) The Semantics of Relationships. Information Science and Knowledge Management, vol 3. Springer, Dordrecht. https://doi.org/10.1007/978-94-017-0073-3_3

Rakison, D. H. (2003). Parts, motion, and the development of the animate-inanimate distinction in infancy. In D. H. Rakison & L. M. Oakes (Eds.), Early category and concept development: Making sense of the blooming, buzzing confusion (p. 159–192). Oxford University Press.

Rakison, D. H., & Butterworth, G. E. (1998). Infants' attention to object structure in early categorization. *Developmental Psychology*, 34(6), 1310–1325. https://doi.org/10.1037/0012-1649.34.6.1310

Rakison, D. H., & Oakes, L. M. (Eds.). (2003). Early category and concept development: Making sense of the blooming, buzzing confusion. Oxford University Press.

Ramsey, R., Cross, E.S. & de C. Hamilton, A.F. (2013). Supramodal and modality-sensitive representations of perceived action categories in the human brain. *Exp Brain Res* 230, 345–357. https://doi.org/10.1007/s00221-013-3659-1

Rifkin, A. (1985). Evidence for a basic level in event taxonomies. *Memory & Cognition*, 13(6), 538–556. https://doi.org/10.3758/BF03198325

Riggio, L., Patteri, I., Oppo, A., Buccino, G., & Umiltà, C. (2006). The role of affordances in inhibition of return. *Psychonomic bulletin & review*, 13(6), 1085–1090. https://doi.org/10.3758/bf03213930

Rizzolatti, G., & Matelli, M. (2003). Two different streams form the dorsal visual system: anatomy and functions. *Experimental brain research*, 153(2), 146–157. https://doi.org/10.1007/s00221-003-1588-0

Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. *Annual review of neuroscience*, 27, 169–192. https://doi.org/10.1146/annurev.neuro.27.070203.144230

Rizzolatti, G., & Sinigaglia, C. (2010). The functional role of the parieto-frontal mirror circuit: interpretations and misinterpretations. *Nature reviews. Neuroscience*, 11(4), 264–274. https://doi.org/10.1038/nrn2805

Rosch, E., Mervis, C., Gray, W.D., Johnson, D.M., & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology*, 8, 382-439. https://doi.org/10.1016/0010-0285(76)90013-X

Rossion, B., & Pourtois, G. (2004). Revisiting Snodgrass and Vanderwart's object pictorial set: the role of surface detail in basic-level object recognition. *Perception*, 33(2), 217–236. https://doi.org/10.1068/p5117

Sakata, H., Taira, M., Murata, A., & Mine, S. (1995). Neural mechanisms of visual guidance of hand action in the parietal cortex of the monkey. *Cerebral cortex* (New York, N.Y.: 1991), 5(5), 429–438. https://doi.org/10.1093/cercor/5.5.429

Sakreida, K., Effnert, I., Thill, S., Menz, M. M., Jirak, D., Eickhoff, C. R., Ziemke, T., Eickhoff, S. B., Borghi, A. M., & Binkofski, F. (2016). Affordance processing in segregated parieto-frontal dorsal stream sub-pathways. *Neuroscience and biobehavioral reviews*, 69, 89–112. https://doi.org/10.1016/j.neubiorev.2016.07.032

Salmon, J. P., McMullen, P. A., & Filliter, J. H. (2010). Norms for two types of manipulability (graspability and functional usage), familiarity, and age of acquisition for 320 photographs of objects. *Behavior research methods*, 42(1), 82–95. https://doi.org/10.3758/BRM.42.1.82

Salmon, J. P., Matheson, H. E., & McMullen, P. A. (2014). Photographs of manipulable objects are named more quickly than the same objects depicted as line-drawings: Evidence that photographs engage embodiment more than line-drawings. *Frontiers in psychology*, 5, 1187. https://doi.org/10.3389/fpsyg.2014.01187

Samuelson, L. K., & Smith, L. B. (1999). Early noun vocabularies: do ontology, category structure and syntax correspond? *Cognition*, 73(1), 1–33. https://doi.org/10.1016/s0010-0277(99)00034-7

Samuelson, L. K., & Smith, L. B. (2005). They call it like they see it: Spontaneous naming and attention to shape. *Developmental Science*, 8(2), 182–198. https://doi.org/10.1111/j.1467-7687.2005.00405.x

Sanfeliu, M.C., Fernandez, A. (1996). A set of 254 Snodgrass-Vanderwart pictures standardized for Spanish: Norms for name agreement, image agreement, familiarity, and visual complexity. *Behavior Research Methods, Instruments, & Computers* 28, 537–555. https://doi.org/10.3758/BF03200541

Sass, K., Sachs, O., Krach, S., Kircher, T. (2009). Taxonomic and thematic categories: Neural correlates of categorization in an auditory-to-visual priming task using fMRI. *Brain Research*, 1270, 78-87. https://doi.org/10.1016/j.brainres.2009.03.013

Schwartz, M. F., Kimberg, D. Y., Walker, G. M., Brecher, A., Faseyitan, O. K., Dell, G. S., Mirman, D., & Coslett, H. B. (2011). Neuroanatomical dissociation for taxonomic and thematic knowledge in the human brain. Proceedings of the National Academy of Sciences of the United States of America, 108(20), 8520–8524. https://doi.org/10.1073/pnas.1014935108

Sheya, A., & Smith, L. B. (2006). Perceptual Features and the Development of Conceptual Knowledge. *Journal of Cognition and Development*, 7(4), 455–476. https://doi.org/10.1207/s15327647jcd0704_2

Shylaja, K., & Manjula, R. (2016). Assessment of Superordinate Categorization in 2-4 years Typically Developing Children. *Journal of Communication Disorders, Deaf Studies & Hearing Aids*, 4, 1-11. https://doi.org/10.4172/2375-4427.1000161

Sirois, M., Kremin, H., & Cohen, H. (2006). Picture-naming norms for Canadian French: name agreement, familiarity, visual complexity, and age of acquisition. *Behavior research methods*, 38(2), 300–306. https://doi.org/10.3758/bf03192781

Sloman, S. A. (1997). Explanatory coherence and the induction of properties. *Thinking & Reasoning*, 3(2), 81–110. https://doi.org/10.1080/135467897394374

Smith L. B. (2003). Learning to recognize objects. *Psychological science*, 14(3), 244–250. https://doi.org/10.1111/1467-9280.03439

Smith L. B. (2003). Learning to recognize objects. *Psychological science*, 14(3), 244–250. https://doi.org/10.1111/1467-9280.03439

Smith, E. E., & Medin, D. L. (1981; 2013). Categories and Concepts. Cambridge (MA): Harvard University Press. doi: https://doi.org/10.4159/harvard.9780674866270

Smith, J. D., & Minda, J. P. (2002). Distinguishing prototype-based and exemplar-based processes in dot-pattern category learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 28(4), 800–811. https://doi.org/10.1037/0278-7393.28.4.800

Smith, L. B., & Colunga, E. (2012). Developing categories and concepts. In M. J. Spivey, K. McRae, & M. F. Joanisse (Eds.), Cambridge handbooks in psychology. The Cambridge handbook of psycholinguistics (p. 283–307). Cambridge University Press. https://doi.org/10.1017/CBO9781139029377.019

Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of experimental psychology. Human learning and memory*, 6(2), 174–215. https://doi.org/10.1037//0278-7393.6.2.174

Tanné-Gariépy, J., Rouiller, E. M., & Boussaoud, D. (2002). Parietal inputs to dorsal versus ventral premotor areas in the macaque monkey: evidence for largely segregated visuomotor pathways. *Experimental brain research*, 145(1), 91–103. https://doi.org/10.1007/s00221-002-1078-9

Tare, M. & Gelman, S. (2010). Determining that a label is kind-referring: Factors that influence children's and adults' novel word extensions. *Journal of Child Language*, 37(5), 1007-1026. https://doi.org/10.1017/S0305000909990134

Thill, S., Caligiore, D., Borghi, A.M., Ziemke, T., Baldassarre, G. (2013). Theories and computational models of affordance and mirror systems: An integrative review. *Neuroscience and Biobehavioral Review*. Volume 37, Issue 3, 2013, Pages 491-521, ISSN 0149-7634, https://doi.org/10.1016/j.neubiorev.2013.01.012.

Tucker, M., & Ellis, R. (2001). The potentiation of grasp types during visual object categorization. *Visual Cognition*, 8(6), 769–800. https://doi.org/10.1080/13506280042000144

Tucker, M., & Ellis, R. (1998). On the relations between seen objects and components of potential actions. *Journal of experimental psychology. Human perception and performance*, 24(3), 830–846. https://doi.org/10.1037//0096-1523.24.3.830

Tversky, B. (1989). Parts, partonomies, and taxonomies. *Developmental Psychology*, 25(6), 983–995. https://doi.org/10.1037/0012-1649.25.6.983

Tversky, B., & Hemenway, K. (1984). Objects, parts, and categories. *Journal of Experimental Psychology: General*, 113(2), 169–193. https://doi.org/10.1037/0096-3445.113.2.169

Ungerleider, L. G., & Mishkin, M. (1982). Two cortical visual systems. In D. J. Ingle, M. A. Goodale, & R. J. W. Mansfield (Eds.), Analysis of visual behavior (pp. 549-586). Cambridge: MIT Press.

Varadarajan K.M., Vincze M. (2013) AfNet: The Affordance Network. In: Lee K.M., Matsushita Y., Rehg J.M., Hu Z. (eds) Computer Vision – ACCV 2012. ACCV 2012. *Lecture Notes in Computer Science*, vol 7724. Springer, Berlin, Heidelberg https://doi.org/10.1007/978-3-642-37331-2_39

Varela, F., Thompson, E., & Rosch, E. (1991). The Embodied Mind: Cognitive Science and Human Experience. MIT Press.

Viggiano, M. P., Vannucci, M., & Righi, S. (2004). A new standardized set of ecological pictures for experimental and clinical research on visual object processing. *Cortex; a journal devoted to the study of the nervous system and behavior*, 40(3), 491–509. https://doi.org/10.1016/s0010-9452(08)70142-4

Ward, Dave & Stapleton, Mog. (2012). Es are good: Cognition as enacted, embodied, embedded, affective and extended. In Fabio Paglieri (ed.), Consciousness in Interaction: The role of the natural and social context in shaping consciousness https://doi.org/10.1075/aicr.86.06war

Warrington, E. K., & Shallice, T. (1984). Category specific semantic impairment. *Brain*, 107, 829-854. https://doi.org/10.1093/brain/107.3.829

Wayne, D. W. (1990). Spearman rank correlation coefficient. Applied Nonparametric Statistics (2nd ed.). Boston: PWS-Kent. pp. 358–365. ISBN 978-0-534-91976-4.

Wilson, M. (2002). Six views of embodied cognition. *Psychonomic Bulletin & Review* 9, 625–636. https://doi.org/10.3758/BF03196322

Wilson, Robert A. and Lucia Foglia, "Embodied Cognition", The Stanford Encyclopedia of Philosophy (Spring 2017 Edition), Edward N. Zalta (ed.). https://plato.stanford.edu/archives/spr2017/entries/embodied-cognition/

Winston, M. E., Chaffin, R., Herrmann, D. J. (1987). A Taxonomy of Part-Whole Relations. *Cognitive Science*. 11, 417-444. https://doi.org/10.1016/S0364-0213(87)80015-0

Wisniewski, E. J. (1996). Construal and Similarity in Conceptual Combination. *Journal of Memory and Language*, 35, 434-453. https://doi.org/10.1006/jmla.1996.0024

Wittgenstein, L. (1953). Philosophical investigations. Philosophische Untersuchungen. Macmillan.

Yoon, E. Y., Humphreys, G. W., & Riddoch, M. J. (2010). The paired-object affordance effect. *Journal of Experimental Psychology: Human Perception and Performance*, 36(4), 812–824. https://doi.org/10.1037/a0017175

Yoon, C., Feinberg, F., Luo, T., Hedden, T., Gutchess, A. H., Chen, H. Y., Mikels, J. A., Jiao, S., & Park, D. C. (2004). A cross-culturally standardized set of pictures for younger and older adults: American and Chinese norms for name agreement, concept agreement, and familiarity. *Behavior research methods, instruments, & computers: a journal of the Psychonomic Society, Inc*, *36*(4), 639–649. https://doi.org/10.3758/bf03206545

Young G. (2006). Are different affordances subserved by different neural pathways? *Brain and cognition*, 62(2), 134–142. https://doi.org/10.1016/j.bandc.2006.04.002

Yu, C., & Smith, L. B. (2007). Rapid word learning under uncertainty via cross-situational statistics. *Psychological science*, 18(5), 414–420. https://doi.org/10.1111/j.1467-9280.2007.01915.x

SITOGRAPHY

http://www.sussex.ac.uk/wordlab/noun

https://dictionary.apa.org/

https://sites.google.com/site/bosstimuli/

https://theaffordances.appspot.com/

APPENDIX A

Table A1. List of the object images, names, categories, structural and functional properties, the level of familiarity for all age groups, and the percentage of familiarity level for pre-schoolers, schoolers, and adults

Q1 	**Name:** Thumb book holder	
	Category: Office supplies	
	Structural properties:	**Shape:** Ring
		Texture: Plastic
		Size: Small
	Functional grasp/use posture: Pinch	
	Familiarity: Low	**Pre-schoolers:** 0%
		Schoolers: 0%
		Adults: 1.39%
Q2 	**Name:** Binder clip	
	Category: Office supplies	
	Structural properties:	**Shape:** Concave structure
		Texture: Iron
		Size: Small
	Functional grasp/use posture: Pinch	
	Familiarity: Medium	**Pre-schoolers:** 15.38%
		Schoolers: 60.78%
		Adults: 90.28%
Q3 	**Name:** Nutcracker	
	Category: Kitchen utensils	
	Structural properties:	**Shape:** Conic cavity
		Texture: Plastic + steel
		Size: Small
	Functional grasp/use posture: Clench + pinch	
	Familiarity: Low	**Pre-schoolers:** 0%
		Schoolers: 0%
		Adults: 6.94%

Q4

Name: Sponge	
Category: Household article	
Structural properties:	**Shape:** Cuboid
	Texture: Sponge
	Size: Small
Functional grasp/use posture: Clench	
Familiarity: High	**Pre-schoolers:** 100%
	Schoolers: 100%
	Adults: 100%

Q5

Name: Hairpin	
Category: Personal care	
Structural properties:	**Shape:** Thin strips
	Texture: Iron
	Size: Small
Functional grasp/use posture: Pinch	
Familiarity: Medium	**Pre-schoolers:** 30.77%
	Schoolers: 39.22%
	Adults: 80.56%

Q6

Name: Wrench	
Category: Tools	
Structural properties:	**Shape:** Flat-concave
	Texture: Steel
	Size: Small
Functional grasp/use posture: Clench	
Familiarity: High	**Pre-schoolers:** 73.08%
	Schoolers: 98.04%
	Adults: 100%

Q7

Name: Nebulizer	
Category: Personal care	
Structural properties:	**Shape:** Spherical
	Texture: Plastic + iron + rubber
	Size: Small
Functional grasp/use posture: Clench + pinch	
Familiarity: Medium	**Pre-schoolers:** 65.38%
	Schoolers: 98.04%
	Adults: 98.61%

Q8 	**Name:** Tube holder	
	Category: Tools	
	Structural properties:	**Shape:** Concave structure
		Texture: Plastic
		Size: Small
	Functional grasp/use posture: Clench	
	Familiarity: Low	**Pre-schoolers:** 0%
		Schoolers: 0%
		Adults: 1.39%
Q9 	**Name:** Fork	
	Category: Kitchen utensils	
	Structural properties:	**Shape:** Sharp tip
		Texture: Steel
		Size: Small
	Functional grasp/use posture: Clench	
	Familiarity: High	**Pre-schoolers:** 100%
		Schoolers: 100%
		Adults: 100%
Q10 	**Name:** Pocket glass	
	Category: Kitchen utensils	
	Structural properties:	**Shape:** Cylindrical
		Texture: Plastic
		Size: Small
	Functional grasp/use posture: Clench	
	Familiarity: Medium	**Pre-schoolers:** 57.69%
		Schoolers: 78.43%
		Adults: 93.06%
Q11 	**Name:** Mouse	
	Category: Office supplies	
	Structural properties:	**Shape:** Flat convexity
		Texture: Plastic
		Size: Small
	Functional grasp/use posture: Clench	
	Familiarity: Medium	**Pre-schoolers:** 65.38%
		Schoolers: 98.04%
		Adults: 100%

Q12 	**Name:** Potato masher	
	Category: Kitchen utensils	
	Structural properties:	**Shape:** Two connected structures
		Texture: Steel
		Size: Small
	Functional grasp/use posture: Clench	
	Familiarity: Medium	**Pre-schoolers:** 38.46%
		Schoolers: 72.55%
		Adults: 90.28%
Q13 	**Name:** Plunger	
	Category: Household article	
	Structural properties:	**Shape:** Conic cavity
		Texture: Wood + rubber
		Size: Small
	Functional grasp/use posture: Clench	
	Familiarity: Medium	**Pre-schoolers:** 23.08%
		Schoolers: 84.31%
		Adults: 97.22%
Q14 	**Name:** Tube squeezer	
	Category: Personal care	
	Structural properties:	**Shape:** Sharp tip
		Texture: Plastic
		Size: Small
	Functional grasp/use posture: Pinch	
	Familiarity: Low	**Pre-schoolers:** 0%
		Schoolers: 0%
		Adults: 8.33%
Q15 	**Name:** Padlock	
	Category: Leisure tools	
	Structural properties:	**Shape:** Two connected structures
		Texture: Steel
		Size: Small
	Functional grasp/use posture: Clench + pinch	
	Familiarity: High	**Pre-schoolers:** 69.23%
		Schoolers: 90.20%
		Adults: 100%

Q16 	**Name:** Screwdriver	
	Category: Tools	
	Structural properties:	**Shape:** Sharp tip
		Texture: Plastic + iron
		Size: Small
	Functional grasp/use posture: Clench	
	Familiarity: High	**Pre-schoolers:** 80.77%
		Schoolers: 98.04%
		Adults: 98.61%
Q17 	**Name:** Earphone	
	Category: Leisure tools	
	Structural properties:	**Shape:** Two connected structures
		Texture: Plastic
		Size: Small
	Functional grasp/use posture: Pinch	
	Familiarity: Medium	**Pre-schoolers:** 38.46%
		Schoolers: 58.82%
		Adults: 80.56%
Q18 	**Name:** Bag shutter	
	Category: Leisure tools	
	Structural properties:	**Shape:** Two connected structures
		Texture: Plastic + iron
		Size: Small
	Functional grasp/use posture: Pinch	
	Familiarity: Low	**Pre-schoolers:** 0%
		Schoolers: 0%
		Adults: 1.39%
Q19 	**Name:** Folding funnel	
	Category: Kitchen utensils	
	Structural properties:	**Shape:** Conic cavity
		Texture: Rubber
		Size: Small
	Functional grasp/use posture: Clench + pinch	
	Familiarity: Low	**Pre-schoolers:** 19.23%
		Schoolers: 37.25%
		Adults: 59.72%

Q20

Name: Whistle	
Category: Leisure tools	
Structural properties:	**Shape:** Concave structure
	Texture: Plastic
	Size: Small
Functional grasp/use posture: Pinch	
Familiarity: High	**Pre-schoolers:** 92.31%
	Schoolers: 98.04%
	Adults: 100%

Q21

Name: Fruit peeler ring	
Category: Kitchen utensils	
Structural properties:	**Shape:** Ring
	Texture: Plastic
	Size: Small
Functional grasp/use posture: Pinch	
Familiarity: Low	**Pre-schoolers:** 0%
	Schoolers: 0%
	Adults: 5.56%

Q22

Name: Tie wrap	
Category: Tools	
Structural properties:	**Shape:** Thin rectilinear
	Texture: Plastic
	Size: Small
Functional grasp/use posture: Pinch	
Familiarity: Medium	**Pre-schoolers:** 15.38%
	Schoolers: 49.02%
	Adults: 54.17%

Q23

Name: Metronome	
Category: Leisure tools	
Structural properties:	**Shape:** Prismatic
	Texture: Plastic + iron
	Size: Small
Functional grasp/use posture: Clench + pinch	
Familiarity: Medium	**Pre-schoolers:** 7.69%
	Schoolers: 45.10%
	Adults: 70.83%

Q24 	**Name:** Cotton swab	
	Category: Personal care	
	Structural properties:	**Shape:** Thin rectilinear
		Texture: Cotton
		Size: Small
	Functional grasp/use posture: Pinch	
	Familiarity: High	**Pre-schoolers:** 92.31%
		Schoolers: 98.04%
		Adults: 100%
Q25 	**Name:** Fruit cutter	
	Category: Kitchen utensils	
	Structural properties:	**Shape:** Two connected structures
		Texture: Plastic + iron
		Size: Small
	Functional grasp/use posture: Clench	
	Familiarity: Low	**Pre-schoolers:** 0%
		Schoolers: 0%
		Adults: 5.56%
Q26 	**Name:** Egg scissors	
	Category: Kitchen utensils	
	Structural properties:	**Shape:** Circular
		Texture: Iron
		Size: Small
	Functional grasp/use posture: Clench	
	Familiarity: Low	**Pre-schoolers:** 3.85%
		Schoolers: 0%
		Adults: 4.17%
Q27 	**Name:** Bottle	
	Category: Kitchen utensils	
	Structural properties:	**Shape:** Cylindrical
		Texture: Plastic
		Size: Small
	Functional grasp/use posture: Clench + pinch	
	Familiarity: High	**Pre-schoolers:** 84.62%
		Schoolers: 94.12%
		Adults: 100%

Q28 	**Name:** Sieve	
	Category: Kitchen utensils	
	Structural properties:	**Shape:** Cylindrical
		Texture: Iron
		Size: Small
	Functional grasp/use posture: Clench	
	Familiarity: Low	**Pre-schoolers:** 15.38%
		Schoolers: 29.41%
		Adults: 56.94%
Q29 	**Name:** Clothespin	
	Category: Household article	
	Structural properties:	**Shape:** Two connected structures
		Texture: Wood + iron
		Size: Small
	Functional grasp/use posture: Pinch	
	Familiarity: High	**Pre-schoolers:** 100%
		Schoolers: 100%
		Adults: 100%
Q30 	**Name:** Tap	
	Category: Household article	
	Structural properties:	**Shape:** Two connected structures
		Texture: Steel
		Size: Small
	Functional grasp/use posture: Clench	
	Familiarity: High	**Pre-schoolers:** 92.31%
		Schoolers: 100%
		Adults: 100%

Table A2. Model summary and parameter estimates of Familiarity, Frequency of Personal Use and Frequency of Observed Use

Model Summary and Parameter Estimates

Dependent Variable: **Familiarity**

Equation	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	.464	127.416	1	147	< .001	27.023	.274		
Quadratic	.569	96.360	2	146	< .001	22.939	.907	-.016	
Cubic	.624	80.298	3	145	< .001	18.405	2.037	-.082	.001

Dependent Variable: **Frequency of Personal Use**

	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	.267	53.643	1	147	< .001	35.785	.576		
Quadratic	.288	29.494	2	146	< .001	30.796	1.348	-.019	
Cubic	.288	19.551	3	145	< .001	31.623	1.142	-.007	< .001

Dependent Variable: **Frequency of Observed Use**

	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	.050	7.657	1	147	.006	53.843	.200		
Quadratic	.055	4.269	2	146	.016	51.705	.531	-.008	
Cubic	.055	2.833	3	145	.040	52.190	.410	-.001	< .001

The independent variable is: **Age**.

Table A3. Classification of objects in high, medium and low Familiarity for each age group based on the results of MDS of Familiarity. For each object the weight on Dimension 1 is specified.

	All age groups	Dim 1	Pre-schoolers	Dim 1	Schoolers	Dim 1	Adults	Dim 1
High familiarity	Clothespin	-.749	Tap	.963	Sponge	-.718	Sponge	-.591
	Bottle	-.749	Clothespin	.963	Wrench	-.718	Wrench	-.591
	Sponge	-.749	Bottle	.963	Fork	-.718	Nebulizer	-.591
	Tap	-.749	Fork	.963	Cotton swab	-.718	Fork	-.591
	Fork	-.749	Sponge	.963	Bottle	-.718	Mouse	-.591
	Whistle	-.699	Whistle	.852	Clothespin	-.718	Padlock	-.591
	Cotton swab	-.678	Cotton swab	.773	Tap	-.718	Whistle	-.591
	Wrench	-.649	Wrench	.699	Whistle	-.656	Cotton swab	-.591
	Nebulizer	-.588	Closable glass	.603	Nebulizer	-.645	Bottle	-.591
	Screwdriver	-.548	Screwdriver	.545	Screwdriver	-.608	Clothespin	-.591
Medium familiarity	Closable glass	-.502	Nebulizer	.388	Mouse	-.586	Tap	-.591
	Mouse	-.451	Mouse	.187	Padlock	-.436	Closable glass	-.523
	Padlock	-.385	Padlock	.131	Closable glass	-.411	Screwdriver	-.494
	Potato masher	-.273	Earphone	.013	Plunger	-.350	Potato masher	-.416
	Plunger	-.224	Egg scissors	-.097	Potato masher	-.261	Plunger	-.393
	Earphone	-.161	Potato masher	-.149	Earphone	-.136	Binder clip	-.322
	Binder clip	-.077	Hairpin	-.228	Binder clip	-.062	Earphone	-.271
	Hairpin	.065	Plunger	-.368	Tie wrap	.123	Hairpin	-.096
	Tie wrap	.160	Tie wrap	-.382	Hairpin	.223	Tie wrap	.050
	Metronome	.260	Folding funnel	-.439	Folding funnel	.321	Metronome	.101
Low familiarity	Folding funnel	.328	Binder clip	-.511	Metronome	.392	Folding funnel	.235
	Sieve	.465	Sieve	-.568	Sieve	.571	Sieve	.353
	Egg scissors	.741	Metronome	-.634	Egg scissors	.735	Egg scissors	.815
	Fruit cutter	.860	Fruit peeler ring	-.747	Fruit cutter	.845	Tube holder	.907
	Tube holder	.914	T. book holder	-.789	Nutcracker	.899	Fruit cutter	.949
	Nutcracker	.946	Fruit cutter	-.818	Tube holder	.947	Nutcracker	1.005
	Fruit peeler ring	1.014	Bag shutter	-.818	Bag shutter	1.013	Fruit peeler ring	1.081
	Bag shutter	1.042	Tube squeezer	-.818	T. book holder	1.036	Tube squeezer	1.127
	Tube squeezer	1.074	Tube holder	-.818	Tube squeezer	1.036	Bag shutter	1.165
	T. book holder	1.106	Nutcracker	-.818	Peeler ring	1.036	T. book holder	1.223

Table A4

Classification of objects in high, medium, and low Frequency of Personal Use for each age group based on the results of MDS. For each object, the weight on Dimension 1 is specified.

	All age groups	Dim 1	Pre-schoolers	Dim 1	Schoolers	Dim 1	Adults	Dim 1
High Frequency of Personal Use	Fork	1,225	Fork	1,422	Fork	-1,290	Fork	1,086
	Tap	1,188	Tap	1,332	Tap	-1,258	Tap	1,066
	Bottle	1,153	Bottle	1,276	Bottle	-1,253	Mouse	1,030
	Cotton swab	,939	Cotton swab	,993	Cotton swab	-1,014	Bottle	1,003
	Mouse	,883	Clothespin	,710	Mouse	-,884	Sponge	,926
	Clothespin	,768	Sponge	,579	Clothespin	-,664	Clothespin	,879
	Sponge	,723	Whistle	,520	Sponge	-,585	Cotton swab	,760
	Padlock	,462	Pocket glass	,503	Whistle	-,440	Padlock	,560
	Whistle	,332	Mouse	,357	Nebulizer	-,419	Screwdriver	,396
	Screwdriver	,301	Nebulizer	,257	Padlock	-,321	Potato masher	,278
Medium Frequency of Personal Use	Pocket glass	,206	Sieve	,203	Screwdriver	-,180	Binder clip	,232
	Nebulizer	,167	Screwdriver	,104	Earphone	-,143	Wrench	,190
	Wrench	,075	Tube squeezer	,039	Pocket glass	-,050	Pocket glass	,132
	Binder clip	,028	Wrench	-,031	Binder clip	,037	Whistle	,082
	Potato masher	-,018	Earphone	-,123	Wrench	,107	Plunger	,029
	Sieve	-,111	Padlock	-,190	Potato masher	,150	Nebulizer	-,077
	Plunger	-,161	Binder clip	-,283	Sieve	,212	Sieve	-,129
	Earphone	-,225	Folding funnel	-,320	Tie wrap	,253	Hairpin	-,206
	Tie wrap	-,325	Plunger	-,394	Plunger	,346	Folding funnel	-,287
	Hairpin	-,373	Hairpin	-,433	Folding funnel	,400	Earphone	-,359
Low Frequency of Personal Use	Folding funnel	-,417	Potato masher	-,443	Metronome	,464	Tie wrap	-,414
	Metronome	-,520	Egg scissors	-,523	Hairpin	,557	Metronome	-,511
	Bag shutter	-,646	Fruit peeler ring	-,559	Tube squeezer	,636	Bag shutter	-,665
	Tube squeezer	-,699	Bag shutter	-,606	Fruit peeler ring	,685	Tube squeezer	-,766
	Fruit peeler ring	-,765	Nutcracker	-,651	Bag shutter	,706	Tube holder	-,826
	Tube holder	-,789	Fruit cutter	-,674	Tube holder	,737	Fruit cutter	-,849
	Nutcracker	-,820	Tie wrap	-,710	Nutcracker	,766	Egg scissors	-,863
	Egg scissors	-,835	Tube holder	-,752	T. book holder	,806	Fruit peeler ring	-,877
	Fruit cutter	-,867	T. book holder	-,766	Fruit cutter	,815	Nutcracker	-,909
	T. book holder	-,877	Metronome	-,838	Egg scissors	,823	T. book holder	-,912

Table A5. Classification of objects in high, medium and low Frequency of Observed Use for each age group based on the results of MDS. For each object, the weight on Dimension 1 is specified.

	All age groups	Dim 1	Pre-schoolers	Dim 1	Schoolers	Dim 1	Adults	Dim 1
High Frequency of Observed Use	Fork	1,063	Fork	1,168	Fork	-1,073	Fork	-1,004
	Tap	1,033	Tap	1,109	Bottle	-1,042	Tap	-,995
	Bottle	1,012	Bottle	1,089	Tap	-1,025	Mouse	-,962
	Clothespin	,913	Sponge	,986	Sponge	-,916	Bottle	-,940
	Sponge	,879	Clothespin	,951	Clothespin	-,882	Clothespin	-,872
	Mouse	,810	Cotton swab	,752	Mouse	-,782	Sponge	-,808
	Cotton swab	,701	Mouse	,554	Cotton swab	-,728	Cotton swab	-,680
	Screwdriver	,502	Screwdriver	,463	Screwdriver	-,551	Padlock	-,569
	Padlock	,454	Wrench	,382	Whistle	-,480	Screwdriver	-,441
	Whistle	,389	Whistle	,330	Wrench	-,391	Wrench	-,377
Medium Frequency of Observed Use	Wrench	,347	Pocket glass	,274	Padlock	-,349	Whistle	-,340
	Potato masher	,253	Sieve	,210	Nebulizer	-,291	Potato masher	-,281
	Nebulizer	,185	Nebulizer	,158	Potato masher	-,202	Binder clip	-,176
	Binder clip	,076	Padlock	,022	Binder clip	-,050	Earphone	-,128
	Earphone	,018	Potato masher	-,011	Earphone	,002	Plunger	-,080
	Pocket glass	-,034	Plunger	-,121	Pocket glass	,081	Nebulizer	-,015
	Plunger	-,067	Tube squeezer	-,165	Plunger	,125	Hairpin	,048
	Sieve	-,176	Binder clip	-,263	Tie wrap	,210	Pocket glass	,082
	Hairpin	-,244	Folding funnel	-,346	Sieve	,287	Sieve	,198
	Tie wrap	-,321	Earphone	-,386	Folding funnel	,388	Tie wrap	,294
Low Frequency of Observed Use	Folding funnel	-,416	Hairpin	-,441	Metronome	,463	Metronome	,351
	Metronome	-,467	Tie wrap	-,520	Hairpin	,509	Folding funnel	,437
	Bag shutter	-,678	Nutcracker	-,581	Bag shutter	,659	Bag shutter	,720
	Tube squeezer	-,741	Fruit peeler ring	-,620	Tube squeezer	,718	Tube squeezer	,816
	Nutcracker	-,820	Fruit cutter	-,682	Tube holder	,798	Nutcracker	,881
	Fruit cutter	-,869	Bag shutter	-,761	Nutcracker	,822	Fruit cutter	,921
	Tube holder	-,903	Metronome	-,797	Fruit peeler ring	,869	Tube holder	,945
	Fruit peeler ring	-,930	Tube holder	-,873	Fruit cutter	,909	Egg scissors	,967
	Egg scissors	-,972	Egg scissors	-,929	T. book holder	,946	Fruit peeler ring	,995
	T. book holder	-,993	T. book holder	-,954	Egg scissors	,976	T. book holder	1,012

Figure A1. Scatter graph of the interaction between objects of high familiarity, and frequency of personal use, across three age groups

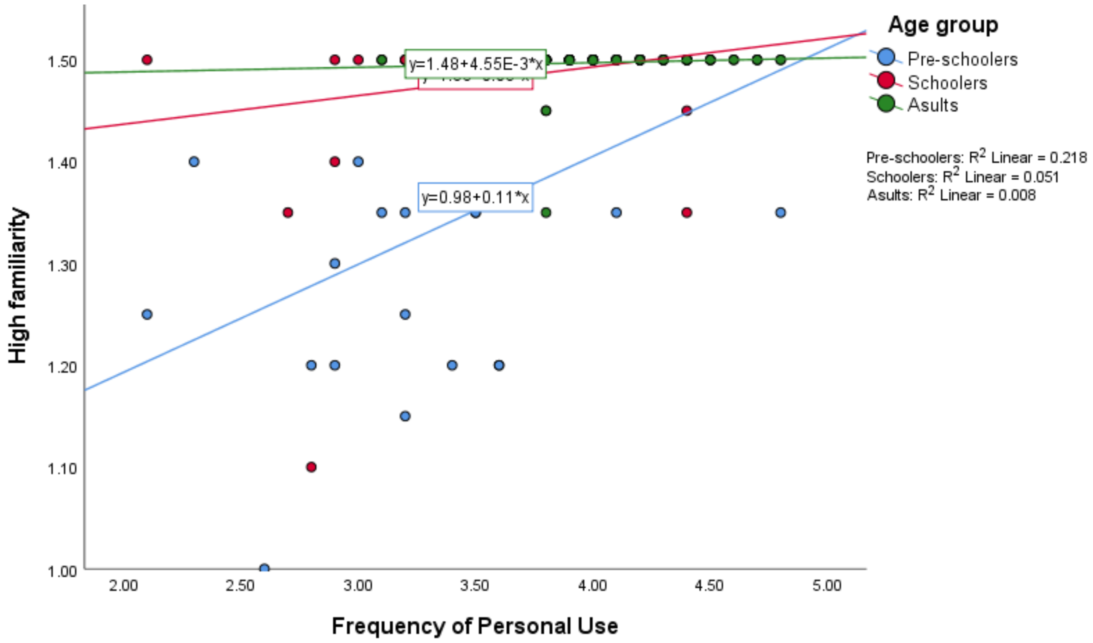


Figure A2. Scatter graph of the interaction between objects of high familiarity, and frequency of observed use, across three age groups

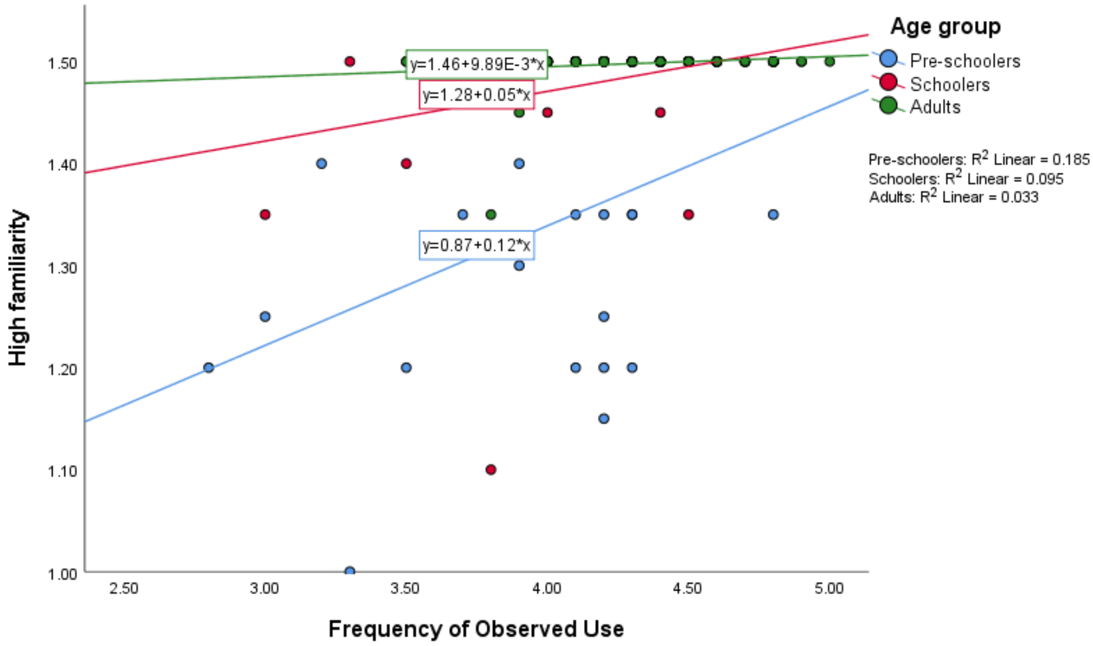


Figure A3. Scatter graph of the interaction between objects of medium familiarity, and frequency of personal use, across three age groups

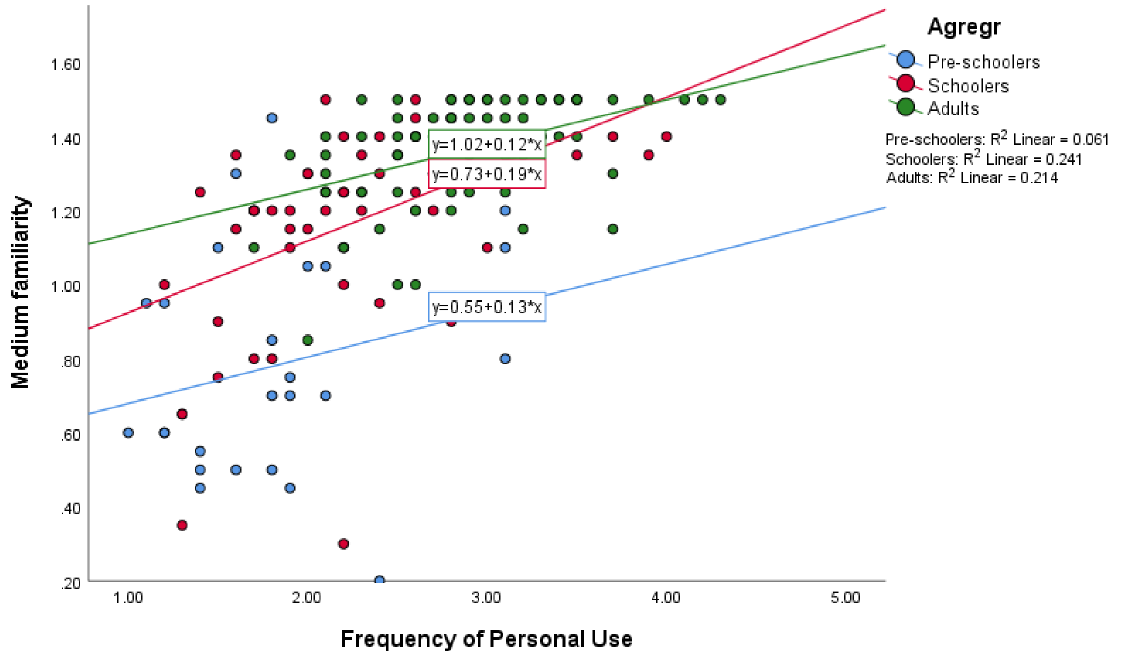


Figure A4. Scatter graph of the interaction between objects of medium familiarity, and frequency of observed use, across three age groups

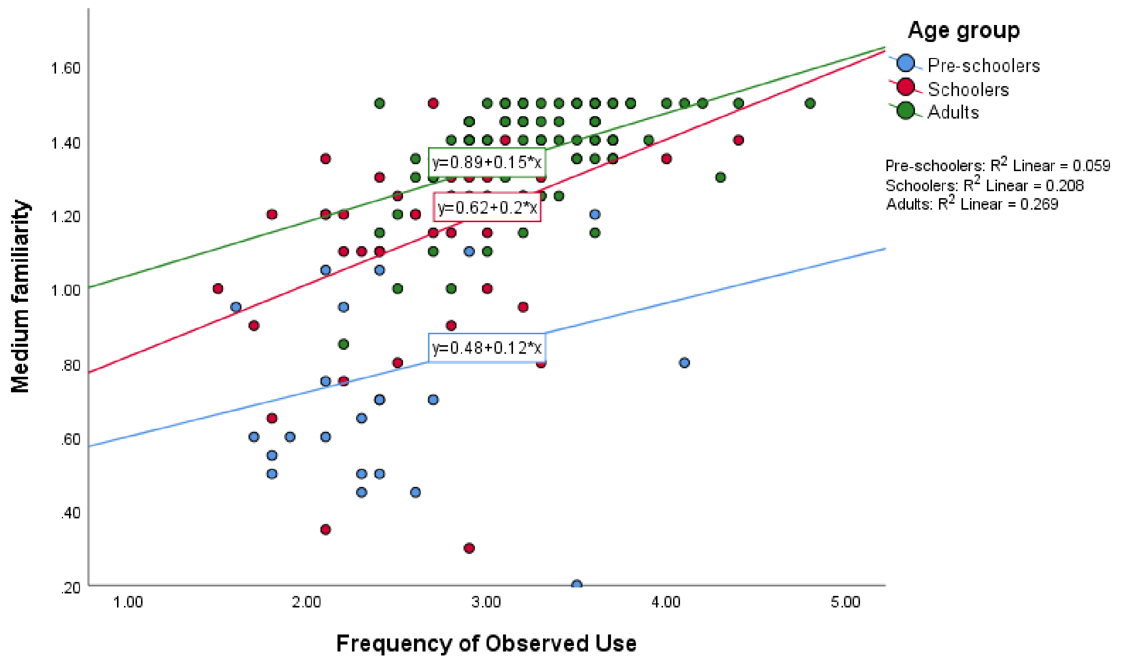


Figure A5. Scatter graph of the interaction between objects of low familiarity, and frequency of personal use, across three age groups

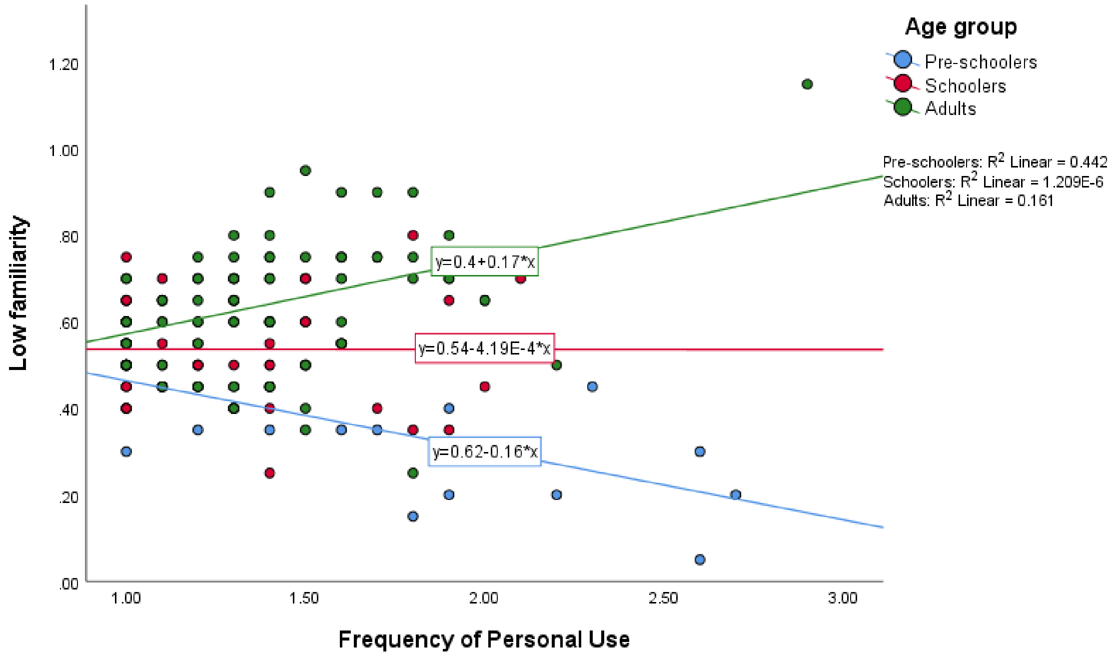


Figure A6. Scatter graph of the interaction between objects of low familiarity, and frequency of observed use, across three age groups

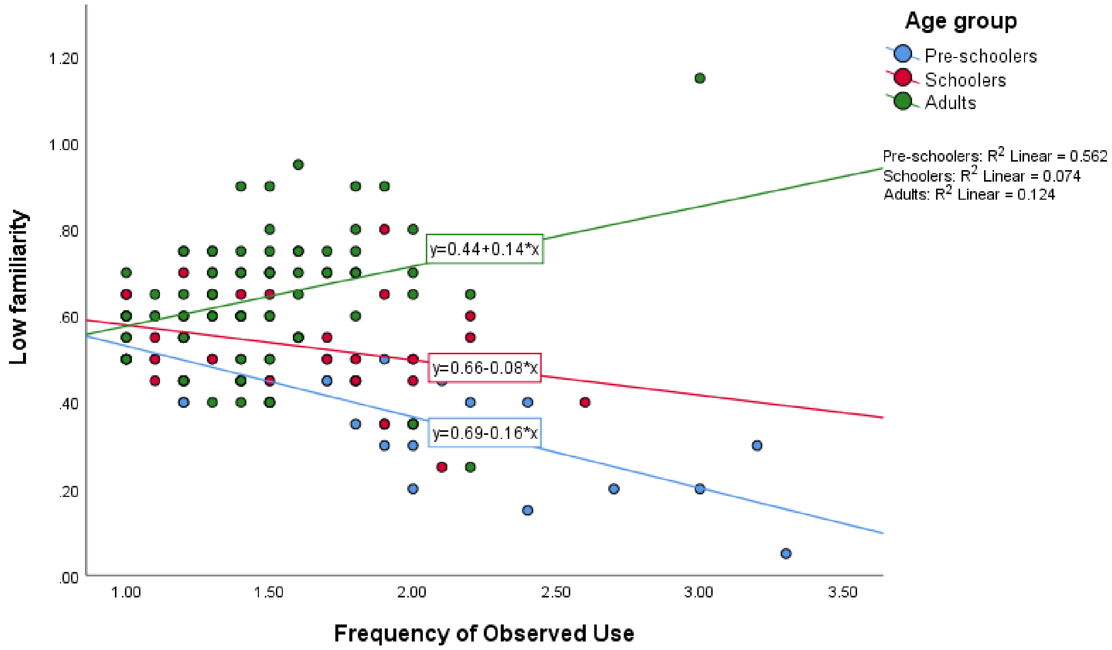


Table A6. Percentage of Familiarity responses based on coding Criterion 2, in pre-schooler, schoolers, adults

Object	Preschoolers				Schoolers				Adults			
	Yes	YesAA	No	NoIA	Yes	YesAA	No	NoIA	Yes	YesAA	No	NoIA
Thumb book holder	0.00%	11.54%	88.46%	0.00%	0.00%	1.96%	98.04%	0.00%	1.39%	2.78%	95.83%	0.00%
Binder clip	15.38%	30.77%	50.00%	3.85%	60.78%	11.76%	21.57%	5.88%	90.28%	5.56%	2.78%	1.39%
Nutcracker	0.00%	30.77%	69.23%	0.00%	0.00%	15.69%	78.43%	5.88%	6.94%	2.78%	88.89%	1.39%
Sponge	100%	0.00%	0.00%	0.00%	100%	0.00%	0.00%	0.00%	100%	0.00%	0.00%	0.00%
Hairpin	30.77%	15.38%	53.85%	0.00%	39.22%	1.96%	47.06%	11.76%	80.56%	0.00%	18.06%	1.39%
Wrench	73.08%	23.08%	3.85%	0.00%	98.04%	0.00%	0.00%	1.96%	100%	0.00%	0.00%	0.00%
Nebulizer	65.38%	15.38%	15.38%	3.85%	98.04%	0.00%	1.96%	0.00%	98.61%	0.00%	0.00%	1.39%
Tube holder	0.00%	15.38%	84.62%	0.00%	3.92%	5.88%	88.24%	1.96%	1.39%	4.17%	79.17%	15.28%
Fork	100%	0.00%	0.00%	0.00%	100%	0.00%	0.00%	0.00%	100%	0.00%	0.00%	0.00%
Pocket glass	57.69%	19.23%	3.85%	19.23%	78.43%	5.88%	5.88%	9.80%	93.06%	1.39%	0.00%	5.56%
Mouse	65.38%	15.38%	15.38%	3.85%	98.04%	0.00%	1.96%	0.00%	100%	0.00%	0.00%	0.00%
Potato masher	38.46%	19.23%	42.31%	0.00%	72.55%	15.69%	9.80%	1.96%	90.28%	5.56%	1.39%	2.78%
Plunger	23.08%	57.69%	19.23%	0.00%	84.31%	7.84%	5.88%	1.96%	97.22%	0.00%	2.78%	0.00%
Tube squeezer	0.00%	76.92%	23.08%	0.00%	0.00%	27.45%	72.55%	0.00%	8.33%	12.50%	79.17%	0.00%
Padlock	69.23%	7.69%	23.08%	0.00%	90.20%	3.92%	5.88%	0.00%	100%	0.00%	0.00%	0.00%
Screwdriver	80.77%	15.38%	3.85%	0.00%	98.04%	1.96%	0.00%	0.00%	98.61%	1.39%	0.00%	0.00%
Earphone	38.46%	11.54%	42.31%	7.69%	58.82%	5.88%	19.61%	15.69%	80.56%	2.78%	6.94%	9.72%
Bag shutter	0.00%	42.31%	57.69%	0.00%	0.00%	19.61%	78.43%	1.96%	1.39%	27.78%	63.89%	6.94%
Folding funnel	19.23%	30.77%	50.00%	0.00%	37.25%	5.88%	45.10%	11.76%	59.72%	1.39%	30.56%	8.33%
Whistle	92.31%	3.85%	3.85%	0.00%	98.04%	0.00%	1.96%	0.00%	100%	0.00%	0.00%	0.00%
Fruit peeler ring	0.00%	26.92%	73.08%	0.00%	0.00%	9.80%	90.20%	0.00%	5.56%	2.78%	90.28%	1.39%
Tie wrap	15.38%	15.38%	65.38%	3.85%	49.02%	5.88%	37.25%	7.84%	54.17%	5.56%	19.44%	20.83%
Metronome	7.69%	23.08%	65.38%	3.85%	45.10%	11.76%	37.25%	5.88%	70.83%	5.56%	18.06%	5.56%
Cotton swab	92.31%	3.85%	3.85%	0.00%	98.04%	1.96%	0.00%	0.00%	100%	0.00%	0.00%	0.00%
Fruit cutter	0.00%	38.46%	61.54%	0.00%	0.00%	3.92%	88.24%	7.84%	5.56%	1.39%	83.33%	9.72%
Egg scissors	3.85%	30.77%	42.31%	23.08%	0.00%	1.96%	76.47%	21.57%	4.17%	2.78%	73.61%	19.44%
Bottle	84.62%	15.38%	0.00%	0.00%	94.12%	5.88%	0.00%	0.00%	100%	0.00%	0.00%	0.00%
Sieve	15.38%	61.54%	23.08%	0.00%	29.41%	29.41%	39.22%	1.96%	56.94%	18.06%	23.61%	1.39%
Clothespin	100%	0.00%	0.00%	0.00%	100%	0.00%	0.00%	0.00%	100%	0.00%	0.00%	0.00%
Tap	92.31%	7.69%	0.00%	0.00%	100%	0.00%	0.00%	0.00%	100%	0.00%	0.00%	0.00%

Table A7. Percentage of Frequency of Personal Use responses, in pre-schooler, schoolers, adults

Object	Preschoolers					Schoolers					Adults				
	Never	Rarely	Sometimes	Often	Very often	Never	Rarely	Sometimes	Often	Very often	Never	Rarely	Sometimes	Often	Very often
Thumb book holder	88.46%	3.85%	7.69%	0.00%	0.00%	96.08%	1.96%	0.00%	1.96%	0.00%	95.83%	2.78%	1.39%	0.00%	0.00%
Binder clip	69.23%	3.85%	23.08%	0.00%	3.85%	37.25%	23.53%	27.45%	7.84%	3.92%	9.72%	13.89%	51.39%	15.28%	9.72%
Nutcracker	76.92%	3.85%	15.38%	3.85%	0.00%	90.20%	7.84%	1.96%	0.00%	0.00%	95.83%	1.39%	1.39%	0.00%	1.39%
Sponge	11.54%	7.69%	65.38%	0.00%	15.38%	7.84%	19.61%	35.29%	9.80%	27.45%	0.00%	0.00%	5.56%	19.44%	75.00%
Hairpin	76.92%	0.00%	11.54%	7.69%	3.85%	76.47%	5.88%	11.76%	1.96%	3.92%	37.50%	15.28%	22.22%	19.44%	5.56%
Wrench	42.31%	11.54%	42.31%	0.00%	3.85%	41.18%	19.61%	29.41%	9.80%	0.00%	6.94%	18.06%	51.39%	15.28%	8.33%
Nebulizer	34.62%	7.69%	34.62%	19.23%	3.85%	25.49%	15.69%	25.49%	13.73%	19.61%	27.78%	19.44%	29.17%	18.06%	5.56%
Tube holder	80.77%	7.69%	7.69%	3.85%	0.00%	92.16%	1.96%	5.88%	0.00%	0.00%	94.44%	1.39%	2.78%	1.39%	0.00%
Fork	0.00%	0.00%	0.00%	7.69%	92.31%	0.00%	0.00%	0.00%	5.88%	94.12%	0.00%	0.00%	0.00%	2.78%	97.22%
Pocket glass	26.92%	3.85%	30.77%	19.23%	19.23%	33.33%	15.69%	39.22%	3.92%	7.84%	12.50%	20.83%	41.67%	16.67%	8.33%
Mouse	30.77%	11.54%	30.77%	15.38%	11.54%	0.00%	9.80%	21.57%	21.57%	47.06%	0.00%	1.39%	1.39%	6.94%	90.28%
Potato masher	76.92%	11.54%	7.69%	0.00%	3.85%	39.22%	29.41%	23.53%	3.92%	3.92%	12.50%	11.11%	45.83%	22.22%	8.33%
Plunger	69.23%	7.69%	23.08%	0.00%	0.00%	60.78%	15.69%	15.69%	7.84%	0.00%	6.94%	29.17%	47.22%	12.50%	4.17%
Tube squeezer	42.31%	11.54%	30.77%	11.54%	3.85%	78.43%	9.80%	7.84%	1.96%	1.96%	84.72%	8.33%	5.56%	1.39%	0.00%
Padlock	65.38%	3.85%	26.92%	0.00%	3.85%	15.69%	27.45%	25.49%	17.65%	13.73%	2.78%	4.17%	31.94%	33.33%	27.78%
Screwdriver	42.31%	19.23%	23.08%	3.85%	11.54%	25.49%	25.49%	27.45%	13.73%	7.84%	2.78%	8.33%	41.67%	37.50%	9.72%
Earphone	65.38%	3.85%	15.38%	7.69%	7.69%	45.10%	9.80%	13.73%	21.57%	9.80%	43.06%	16.67%	25.00%	8.33%	6.94%
Bag shutter	80.77%	3.85%	7.69%	7.69%	0.00%	90.20%	5.88%	1.96%	0.00%	1.96%	75.00%	4.17%	11.11%	6.94%	2.78%
Folding funnel	69.23%	15.38%	11.54%	0.00%	3.85%	70.59%	3.92%	13.73%	5.88%	5.88%	51.39%	5.56%	13.89%	18.06%	11.11%
Whistle	19.23%	0.00%	53.85%	23.08%	3.85%	9.80%	7.84%	60.78%	13.73%	7.84%	5.56%	26.39%	50.00%	9.72%	8.33%
Fruit peeler ring	76.92%	7.69%	7.69%	3.85%	3.85%	90.20%	1.96%	5.88%	0.00%	1.96%	94.44%	2.78%	2.78%	0.00%	0.00%
Tie wrap	80.77%	7.69%	11.54%	0.00%	0.00%	50.98%	17.65%	19.61%	9.80%	1.96%	38.89%	20.83%	26.39%	12.50%	1.39%
Metronome	92.31%	0.00%	7.69%	0.00%	0.00%	70.59%	5.88%	15.69%	1.96%	5.88%	51.39%	18.06%	18.06%	8.33%	4.17%
Cottonswab	7.69%	11.54%	19.23%	19.23%	42.31%	3.92%	5.88%	7.84%	29.41%	52.94%	0.00%	8.33%	9.72%	29.17%	52.78%
Fruit cutter	84.62%	3.85%	7.69%	0.00%	3.85%	98.04%	0.00%	1.96%	0.00%	0.00%	94.44%	1.39%	2.78%	1.39%	0.00%
Egg scissors	76.92%	7.69%	7.69%	7.69%	0.00%	98.04%	1.96%	0.00%	0.00%	0.00%	94.44%	1.39%	4.17%	0.00%	0.00%
Bottle	0.00%	0.00%	11.54%	11.54%	76.92%	0.00%	0.00%	0.00%	9.80%	90.20%	2.78%	1.39%	0.00%	8.33%	87.50%
Sieve	42.31%	11.54%	23.08%	11.54%	11.54%	52.94%	15.69%	19.61%	1.96%	9.80%	36.11%	9.72%	29.17%	16.67%	8.33%
Clothespin	19.23%	3.85%	46.15%	7.69%	23.08%	7.84%	3.92%	45.10%	21.57%	21.57%	1.39%	1.39%	5.56%	19.44%	72.22%
Tap	0.00%	3.85%	3.85%	15.38%	76.92%	0.00%	0.00%	0.00%	9.80%	90.20%	0.00%	0.00%	0.00%	5.56%	94.44%

Table A8. Percentage of Frequency of Observed Use responses, in pre-schooler, schoolers, adults

Object	Preschoolers					Schoolers					Adults				
	Never	**Rarely**	**Sometimes**	**Often**	**Very often**	**Never**	**Rarely**	**Sometimes**	**Often**	**Very often**	**Never**	**Rarely**	**Sometimes**	**Often**	**Very often**
Thumb book holder	76.92%	7.69%	15.38%	0.00%	0.00%	90.20%	7.84%	0.00%	1.96%	0.00%	95.83%	2.78%	0.00%	1.39%	0.00%
Binder clip	30.77%	23.08%	34.62%	7.69%	3.85%	15.69%	17.65%	45.10%	13.73%	7.84%	4.17%	6.94%	56.94%	26.39%	5.56%
Nutcracker	46.15%	19.23%	30.77%	3.85%	0.00%	76.47%	13.73%	5.88%	3.92%	0.00%	86.11%	9.72%	2.78%	0.00%	1.39%
Sponge	0.00%	3.85%	11.54%	15.38%	69.23%	0.00%	0.00%	5.88%	25.49%	68.63%	0.00%	1.39%	4.17%	26.39%	68.06%
Hairpin	46.15%	19.23%	11.54%	15.38%	7.69%	52.94%	11.76%	23.53%	3.92%	7.84%	20.83%	6.94%	31.94%	33.33%	6.94%
Wrench	3.85%	19.23%	38.46%	34.62%	3.85%	0.00%	11.76%	49.02%	23.53%	15.69%	0.00%	2.78%	50.00%	33.33%	13.89%
Nebulizer	15.38%	11.54%	42.31%	15.38%	15.38%	11.76%	9.80%	37.25%	15.69%	25.49%	8.33%	26.39%	33.33%	22.22%	9.72%
Tube holder	61.54%	19.23%	11.54%	3.85%	3.85%	80.39%	5.88%	11.76%	0.00%	1.96%	91.67%	4.17%	2.78%	1.39%	0.00%
Fork	0.00%	0.00%	0.00%	7.69%	92.31%	0.00%	0.00%	0.00%	1.96%	98.04%	0.00%	0.00%	0.00%	1.39%	98.61%
Pocket glass	11.54%	15.38%	34.62%	19.23%	19.23%	25.49%	9.80%	49.02%	7.84%	7.84%	8.33%	18.06%	54.17%	12.50%	6.94%
Mouse	11.54%	7.69%	30.77%	23.08%	26.92%	0.00%	1.96%	15.69%	27.45%	54.90%	0.00%	0.00%	1.39%	8.33%	90.28%
Potato masher	23.08%	23.08%	23.08%	23.08%	7.69%	11.76%	7.84%	43.14%	25.49%	11.76%	4.17%	8.33%	44.44%	30.56%	12.50%
Plunger	23.08%	7.69%	65.38%	0.00%	3.85%	17.65%	23.53%	49.02%	7.84%	1.96%	2.78%	16.67%	52.78%	25.00%	2.78%
Tube squeezer	30.77%	15.38%	30.77%	15.38%	7.69%	66.67%	11.76%	15.69%	3.92%	1.96%	76.39%	16.67%	4.17%	2.78%	0.00%
Padlock	15.38%	11.54%	61.54%	7.69%	3.85%	1.96%	13.73%	47.06%	15.69%	21.57%	0.00%	1.39%	27.78%	38.89%	31.94%
Screwdriver	3.85%	3.85%	57.69%	19.23%	15.38%	1.96%	0.00%	35.29%	39.22%	23.53%	0.00%	2.78%	34.72%	47.22%	15.28%
Earphone	42.31%	19.23%	26.92%	3.85%	7.69%	29.41%	13.73%	25.49%	17.65%	13.73%	15.28%	6.94%	36.11%	27.78%	13.89%
Bag shutter	61.54%	11.54%	11.54%	11.54%	3.85%	68.63%	13.73%	9.80%	3.92%	3.92%	70.83%	5.56%	13.89%	6.94%	2.78%
Folding funnel	42.31%	23.08%	23.08%	3.85%	7.69%	49.02%	15.69%	15.69%	13.73%	5.88%	45.83%	8.33%	13.89%	19.44%	12.50%
Whistle	3.85%	11.54%	53.85%	19.23%	11.54%	0.00%	9.80%	39.22%	31.37%	19.61%	1.39%	1.39%	50.00%	29.17%	15.28%
Fruit peeler ring	50.00%	23.08%	15.38%	3.85%	7.69%	78.43%	13.73%	5.88%	0.00%	1.96%	97.22%	0.00%	2.78%	0.00%	0.00%
Tie wrap	42.31%	26.92%	30.77%	0.00%	0.00%	33.33%	17.65%	27.45%	15.69%	5.88%	33.33%	8.33%	30.56%	23.61%	4.17%
Metronome	61.54%	15.38%	19.23%	3.85%	0.00%	45.10%	17.65%	27.45%	1.96%	7.84%	26.39%	23.61%	33.33%	6.94%	9.72%
Cottonswab	7.69%	3.85%	23.08%	23.08%	42.31%	1.96%	1.96%	17.65%	27.45%	50.98%	0.00%	1.39%	13.89%	40.28%	44.44%
Fruit cutter	53.85%	26.92%	15.38%	0.00%	3.85%	84.31%	9.80%	5.88%	0.00%	0.00%	88.89%	5.56%	4.17%	1.39%	0.00%
Egg scissors	69.23%	11.54%	11.54%	7.69%	0.00%	96.08%	1.96%	1.96%	0.00%	0.00%	94.44%	0.00%	5.56%	0.00%	0.00%
Bottle	0.00%	0.00%	3.85%	15.38%	80.77%	0.00%	0.00%	0.00%	7.84%	92.16%	2.78%	0.00%	0.00%	6.94%	90.28%
Sieve	15.38%	11.54%	42.31%	15.38%	15.38%	35.29%	17.65%	29.41%	5.88%	11.76%	27.78%	8.33%	31.94%	23.61%	8.33%
Clothespin	0.00%	3.85%	7.69%	23.08%	65.38%	1.96%	1.96%	5.88%	23.53%	66.67%	0.00%	0.00%	2.78%	18.06%	79.17%
Tap	0.00%	3.85%	0.00%	15.38%	80.77%	0.00%	0.00%	0.00%	9.80%	90.20%	0.00%	0.00%	0.00%	2.78%	97.22%

Table A9. Percentage of modal name (in Italian) agreement computed for preschoolers, schoolers, and adults on the total of the right responses for each age group, on the total of the responses for each age group, on the total of responses given by the whole sample.

Object (English name)	Pre-schoolers modal name	Pre-schoolers modal name 2	% Pre-schoolers right answers	% Pre-schoolers tot age group	Schoolers modal name	% Schoolers right answers	% Schoolers tot age group	Adults modal name	% Adults right answers	% Adults tot age group	% Whole sample right answers	% Whole sample
Thumb book holder			0,00%	0,00%		0,00%	0,00%	fermalibro	100,00%	1,39%	100,00%	0,67%
Binder clip	molletta per i fogli	fermacarte	50,00%	7,69%	molletta per i fogli	80,65%	49,02%	molletta per i fogli	69,23%	62,50%	98,00%	65,77%
Nutcracker			0,00%	0,00%		0,00%	0,00%	schiacciano ci	100,00%	6,94%	100,00%	3,36%
Sponge	spugna		100,00%	100,00%	spugna	100,00%	100,00%	spugna	100,00%	100,00%	100,00%	100,00%
Hairpin	fermaglio per i capelli		100,00%	30,77%	fermaglio per i capelli	100,00%	39,22%	fermaglio per capelli	100,00%	80,56%	100,00%	57,72%
Wrench	chiave		89,47%	65,38%	chiave inglese	89,58%	84,31%	chiave inglese	91,55%	90,28%	89,93%	83,89%
Nebulizer	profumo		87,50%	53,85%	profumo	98,00%	96,08%	boccetta di profumo	94,37%	93,06%	98,55%	91,28%
Tube holder			0,00%	0,00%	gancio	100,00%	3,92%	reggitubo	100,00%	1,39%	100,00%	2,01%
Fork	forchetta		100,00%	100,00%	forchetta	100,00%	100,00%	forchetta	100,00%	100,00%	100,00%	100,00%
Pocket glass	bicchiere		100,00%	57,69%	bicchiere richiudibile	97,50%	76,47%	bicchiere richiudibile	100,00%	93,06%	99,18%	81,21%
Mouse	mouse		56,25%	34,62%	mouse	97,96%	94,12%	mouse	100,00%	100,00%	92,81%	86,58%
Potato masher	schiaccia patate		80,00%	30,77%	schiaccia patate	88,89%	62,75%	schiaccia patate	92,31%	83,33%	92,86%	69,80%
Plunger	sturalavan dino		80,00%	15,38%	sturalavandi no	100,00%	80,39%	sturalavandi no	100,00%	94,44%	94,96%	75,84%
Tube squeezer			0,00%	0,00%		0,00%	0,00%	spremi tubetti	66,67%	5,56%	83,33%	3,36%
Padlock	lucchetto		61,54%	30,77%	lucchetto	88,89%	78,43%	lucchetto	94,44%	94,44%	91,18%	83,22%
Screwdriver	cacciavite		80,00%	61,54%	cacciavite	97,96%	94,12%	cacciavite	100,00%	98,61%	95,07%	90,60%

Earphone	cuffia		90,00%	34,62%	cuffia	90,00%	52,94%	auricolare	98,28%	79,17%	96,94%	63,76%
Bag shutter			0,00%	0,00%		0,00%	0,00%	molletta per sacchetti	100,00%	1,39%	100,00%	0,67%
Folding funnel	imbuto		100,00%	19,23%	imbuto pieghevole	100,00%	37,25%	imbuto pieghevole	100,00%	59,72%	100,00%	44,97%
Whistle	fischietto		95,83%	88,46%	fischietto	100,00%	98,04%	fischietto	100,00%	100,00%	99,32%	97,32%
Fruit peeler ring			0,00%	0,00%		0,00%	0,00%	sbuccia arancia	75,00%	4,17%	75,00%	2,01%
Tie wrap	fascetta		100,00%	15,38%	fascetta	76,00%	37,25%	fascetta	92,31%	50,00%	91,18%	41,61%
Metronome	metronom o		100,00%	7,69%	metronomo	69,57%	31,37%	metronomo	86,27%	61,11%	81,58%	41,61%
Cottonswab	bastoncin o per le orecchie		87,50%	80,77%	cotton fioc	92,00%	90,20%	cotton fioc	98,61%	98,61%	97,95%	95,97%
Fruit cutter			0,00%	0,00%		0,00%	0,00%	affetta frutta	75,00%	4,17%	75,00%	2,01%
Egg scissors			0,00%	0,00%		0,00%	0,00%	taglia uovo	100,00%	4,17%	75,00%	2,01%
Bottle	bottiglia		100,00%	84,62%	bottiglia	100,00%	94,12%	bottiglia	100,00%	100,00%	100,00%	95,30%
Sieve	spolverino		75,00%	11,54%	setaccio	85,71%	23,53%	setaccio	95,12%	54,17%	91,67%	36,91%
Clothespin	molletta per i vestiti		100,00%	100,00%	molletta per il bucato	94,12%	94,12%	molletta per il bucato	100,00%	100,00%	100,00%	100,00%
Tap	lavandino	rubinetto	50,00%	38,46%	rubinetto	72,55%	72,55%	rubinetto	93,06%	93,06%	90,48%	89,26%

Table A10. Information statistic H of name agreement computed for each object on the whole sample and divided for each age group

Object	H all subjects	H Pre-schoolers	H Schoolers	H Adults
Thumb book holder	6,74	-	-	5,55
Binder clip	0,89	3	3,52	1,64
Nutcracker	4,29	-	5,24	3,40
Sponge	0	0	0	0
Hairpin	0,32	1,08	0,48	0,07
Wrench	0,23	0,61	0,18	0,12
Nebulizer	0,60	0,48	0,51	0,74
Tube holder	3,65	-	-	3,26
Fork	0,01	0	0,05	0
Pocket glass	0,14	0,37	0,15	0,02
Mouse	0,07	0,73	0,02	0
Potato masher	0,25	1,24	0,29	0,06
Plunger	0,53	2,70	0,44	0,44
Tube squeezer	4,75	-	-	3,26
Padlock	0,19	0,77	0,26	0,08
Screwdriver	0,042	0,24	0,02	0,02
Earphone	0,81	3,16	1,10	0,41
Bag shutter	6,97	-	-	5,72
Folding funnel	0,60	1,76	0,74	0,32
Whistle	0,01	0,05	0,02	0
Fruit peeler ring	4,98	-	-	3,73
Tie wrap	0,54	2	0,84	0,29
Metronome	0,92	3,16	1,80	0,49
Cottonswab	0,07	0	0,14	0,02
Fruit cutter	2,52	-	2,90	1,25

Egg scissors	3,18	-	-	3,87
Bottle	0,06	0,24	0,08	0
Sieve	1,11	3,45	1,55	0,59
Clothespin	0	0	0	0
Tap	0,44	1,32	0,48	0,31

Table A11. Percentage of modal function (in Italian) agreement computed for preschoolers, schoolers and adults on the total of the right responses for each age group, on the total of the responses for each age group, on the total of responses given by the whole sample.

Object (English name)	Pre-schoolers modal function	% Pre-schoolers right answers	% Pre-schoolers tot age group	Schoolers modal function	% Schoolers right answers	% Schoolers tot age group	Adults modal function	% Adults right answers	% Adults tot age group	% Whole sample right answers	% Whole sample
Thumb book holder		0,00%	0,00%		0,00%	0,00%	mantenere aperte le pagine di un libro	100,00%	1,39%	100,00%	0,67%
Binder clip	tenere insieme i fogli	75,00%	11,54%	tenere insieme i fogli	96,77%	58,82%	tenere insieme i fogli	95,38%	86,11%	95,00%	63,76%
Nutcracker		0,00%	0,00%		0,00%	0,00%	rompere guscio delle noci	100,00%	6,94%	100,00%	3,36%
Sponge	lavare i piatti	96,15%	96,15%	lavare i piatti	100,00%	100,00%	spugna	98,61%	98,61%	98,66%	98,66%
Hairpin	tenere i capelli	100,00%	30,77%	tenere i capelli	94,74%	35,29%	tenere i capelli	89,83%	73,61%	91,86%	53,02%
Wrench	aggiustare qualcosa	68,42%	50,00%	avvitare e svitare	83,67%	80,39%	avvitare e svitare	98,59%	97,22%	84,17%	78,52%
Nebulizer	spruzzare profumo	70,59%	46,15%	spruzzare profumo	58,00%	56,86%	spruzzare profumo	76,06%	75,00%	68,84%	63,76%
Tube holder		0,00%	0,00%	bloccare	100,00%	3,92%	bloccare tubi	100,00%	1,39%	100,00%	2,01%
Fork	mangiare	100,00%	100,00%	mangiare	82,35%	82,35%	mangiare	52,78%	52,78%	71,14%	71,14%
Pocket glass	bere	93,33%	53,85%	bere	90,00%	70,59%	bere	77,61%	72,22%	83,61%	68,46%
Mouse	usare il computer	88,24%	57,69%	muovere il cursore	60,00%	58,82%	muovere il cursore	59,72%	59,72%	52,52%	48,99%
Potato masher	schiaccia patate	90,00%	34,62%	schiaccia patate	97,30%	70,59%	schiaccia patate	93,85%	84,72%	94,64%	71,14%
Plunger	pulire il lavandino	66,67%	15,38%	sturare il lavandino	97,67%	82,35%	sturare il lavandino	98,57%	95,83%	96,64%	77,18%

Tube squeezer		0,00%	0,00%		0,00%	0,00%	spremere tubetti	100,00%	8,33%	100,00%	4,03%
Padlock	chiudere	94,44%	65,38%	chiudere	91,30%	82,35%	chiudere	97,22%	97,22%	94,85%	86,58%
Screwdriver	avvitare e svitare	52,38%	42,31%	avvitare e svitare	92,00%	90,20%	avvitare e svitare	98,59%	97,22%	89,44%	85,23%
Earphone	ascoltare la musica	60,00%	23,08%	ascoltare la musica	80,00%	47,06%	ascoltare la musica	74,14%	59,72%	74,49%	48,99%
Bag shutter		0,00%	0,00%		0,00%	0,00%	chiudere i sacchetti	100,00%	1,39%	100,00%	0,67%
Folding funnel	versare liquidi	100,00%	19,23%	versare liquidi	94,74%	35,29%	versare liquidi	95,35%	56,94%	95,52%	42,95%
Whistle	fischiare	83,33%	76,92%	fischiare	74,00%	72,55%	fischiare	51,39%	51,39%	64,38%	63,09%
Fruit peeler ring		0,00%	0,00%		0,00%	0,00%	sbucciare agrumi	100,00%	5,56%	100,00%	2,68%
Tie wrap	legare	75,00%	11,54%	legare	92,00%	45,10%	legare	87,18%	47,22%	88,24%	40,27%
Metronome	dare il tempo	100,00%	7,69%	scandire il tempo	82,61%	37,25%	scandire il tempo	96,08%	68,06%	92,11%	46,98%
Cottonswab	pulire le orecchie	95,83%	88,46%	pulire le orecchie	98,00%	96,08%	pulire le orecchie	95,83%	95,83%	96,58%	94,63%
Fruit cutter		0,00%	0,00%		0,00%	0,00%	affettare la frutta	100,00%	5,56%	100,00%	2,68%
Egg scissors	tagliare	100,00%	3,85%		0,00%	0,00%	tagliare l'uovo	100,00%	4,17%	100,00%	2,68%
Bottle	bere	100,00%	84,62%	contenere liquidi	54,17%	50,98%	contenere liquidi	73,61%	73,61%	55,63%	53,02%
Sieve	spolverare	80,00%	15,38%	spolverare	92,86%	25,49%	spolverare	95,12%	54,17%	93,33%	37,58%
Clothespin	stendere	92,31%	92,31%	stendere	94,12%	94,12%	stendere	98,61%	98,61%	95,97%	95,97%
Tap	lavare le mani	75,00%	69,23%	far uscire l'acqua	74,51%	74,51%	far uscire l'acqua	80,56%	80,56%	69,39%	68,46%

Table A12. Table of synonym nouns for each age group

Object	Pre-schoolers synonyms	Schoolers synonyms	Adults synonyms
Thumb book holder			ferma libro
Binder clip	pinza per i fogli ~~fermacarte~~ molletta per i fogli	molletta molletta per i fogli pinzetta pinzetta per i fogli ~~fermacarte~~ ~~ferma fogli~~ ~~portadocumenti~~ graffetta graffetta per i fogli clip per i fogli	molletta clip pinza pinza per i fogli pinzetta per i fogli ~~fermacarte~~ graffetta
Nutcracker			schiaccianoci
Sponge	spugna	spugna spugna per i piatti spugna da cucina spugna abrasiva	spugna spugna per i piatti spugna da cucina spugna abrasiva
Hairpin	molletta fermaglio per capelli pinza per capelli fermacapelli	fermaglio per capelli molletta molletta per capelli pinza per capelli pinza fermacapelli	fermacapelli pinza fermaglio per capelli fermaglio molletta molletta per capelli ~~clip~~
Wrench	chiave ~~attrezzo~~ chiave inglese ~~aggiustatutto~~	chiave chiave inglese ~~pinza~~ ~~attrezzo~~	~~pinza~~ chiave chiave inglese chiave a pappagallo ~~sita bulloni~~ ~~tenaglia~~ ~~attrezzo~~
Nebulizer	Profumo spruzza profumo ~~puff puff~~ boccetta di profumo	bottiglietta di profumo profumo ~~bomboletta~~ boccetta per profumo contenitore per profumo profumatore porta profumo ~~diffusore~~ spruzza profumo ~~dosatore~~ nebulizzatore ampolla di profumo	profumo boccetta spruzza profumo boccetta di profumo erogatore profumo nebulizzatore profumo vaporizzatore contenitore di profumo erogatore di profumo diffusore di profumo ampolla di profumo bottiglia di profumo ~~dosatore profumo~~ porta profumo flacone di profumo
Tube holder		gancio	reggitubo
Fork	forchetta	forchetta	forchetta
Pocket glass	Bicchiere bicchiere pieghevole	bicchiere bicchiere che si chiude bicchiere portatile bicchiere richiudibile bicchiere da viaggio bicchiere salvaspazio	bicchiere bicchiere portatile bicchiere pieghevole bicchiere richiudibile bicchiere tascabile bicchiere da viaggio

			bicchiere da pic-nic bicchiere da campeggio bicchiere retraibile
Mouse	mouse mouse del computer	mouse mouse del computer	mouse mouse del computer
Potato masher	schiaccia patate	schiaccia patate ~~utensile da cucina~~	schiaccia patate pressa patate trita patate passa patate ~~schiaccia aglio~~ ~~passa verdure~~
Plunger	ventosa sturalavandino	sturalavandino stura wc ventosa	sturalavandino ventosa stantuffo
Tube squeezer			spremi tubetti ~~arrotolatore~~
Padlock	lucchetto ~~blocco~~	lucchetto ~~catenaccio~~	lucchetto ~~catenaccio~~
Screwdriver	cacciavite giravite	cacciavite giravite	cacciavite giravite
Earphone	cuffia auricolare	cuffia auricolare	cuffia auricolare auricolare bluetooth
Bag shutter			molletta per sacchetti
Folding funnel	imbuto	imbuto imbuto pieghevole imbuto portatile imbuto richiudibile	imbuto imbuto richiudibile imbuto pieghevole imbuto da campeggio imbuto salvaspazio
Whistle	fischietto	fischietto	fischietto
Fruit peeler ring			anello sbuccia arancia sbuccia arancia sbuccia agrumi
Tie wrap	fascetta	fascetta laccetto ~~fermaglio~~ ~~torciglione~~	fascetta laccetto ~~fettuccia~~ stringa
Metronome	metronomo	misura tempo metronomo misuratore tempo porta tempo	metronomo accorda strumenti porta tempo
Cotton swab	bastoncino per le orecchie cotton fioc	cotton fioc bastoncino di cotone ~~pulisci orecchie~~	cotton fioc bastoncino di cotone ~~pulisci orecchie~~
Fruit cutter			affetta frutta taglia frutta taglia kiwi
Egg scissors			taglia uovo
Bottle	bottiglia bottiglia d'acqua	bottiglia bottiglia d'acqua bottiglia di plastica	bottiglia bottiglia d'acqua bottiglia di plastica
Sieve	spolvera zucchero cernitore spolverino	setaccio spargi zucchero spargi farina colino	spargi zucchero setaccio ~~dosatore~~ spargitore

Clothespin	pinzetta molletta molletta per i panni	pinzetta molletta molletta per il bucato molletta per i panni ~~acchiappino~~	molletta pinzetta molletta per il bucato molletta per i panni molletta per gli indumenti
Tap	~~lavandino~~ rubinetto ~~fontana~~	~~lavandino~~ rubinetto ~~fontana~~ miscelatore	~~lavandino~~ rubinetto ~~fontana~~ miscelatore cannella

Note. ~~Nouns~~ have been considered different names.

Table A13. Table of similar function expressions for each age group

Object	Pre-schoolers similar function expressions	Schoolers similar function expressions	Adults similar function expressions
Thumb book holder			mantenere aperte le pagine di un libro
Binder clip	mettere i fogli dentro ~~chiudere i biscotti~~ fermare i fogli fermare la carta	mantenere i fogli fermare i fogli fermare le carte tenere i fogli mantenere le carte ~~non perdere documenti~~ raggruppare fogli fermare i fogli tenere insieme i fogli tenere insieme i documenti bloccare fogli tenere insieme delle carte	mantenere i fogli fermare i fogli raccogliere fogli tenere insieme dei fogli fermare documenti mantenere insieme dei fogli ~~non far volare i fogli~~ tenere uniti dei fogli tenere fermi dei fogli raccogliere carte tenere uniti documenti raccogliere insieme dei fogli bloccare fogli raggruppare fogli fascicolare fermare la carta assemblare fogli ~~trattenere qualcosa~~
Nutcracker			rompere il guscio delle noci
Sponge	pulire la cucina pulire i piatti lavare i piatti lavare strofinare i piatti pulire	pulire i piatti lavare i piatti strofinare i piatti pulire lavare pulire le stoviglie scrostare le padelle eliminare lo sporco lavare le superfici	pulire lavare i piatti pulire i piatti lavare le stoviglie pulire le stoviglie ~~assorbire liquidi~~ pulire superfici pulire oggetti disincrostare fare pulizie detergere
Hairpin	legare i capelli tenere i capelli raccogliere i capelli	tenere i capelli legare i capelli fermare i capelli mantenere i capelli	fermare i capelli ~~fare acconciature~~ mantenere i capelli legare i capelli tenere i capelli raccogliere i capelli ~~acconciare i capelli~~ tenere uniti i capelli tenere insieme i capelli racchiudere i capelli
Wrench	~~aggiustare qualcosa~~ girare aprire e chiudere stringere avvitare e svitare svitare le viti	~~aggiustare qualcosa~~ svitare le viti girare le viti avvitare e svitare avvitare ~~aggiustare i tubi~~ avvitare e svitare i bulloni stringere qualcosa aprire e chiudere stringere bulloni ~~lavorare con tubi~~ girare bulloni	avvitare e svitare ruotare bulloni smontare avvitare e svitare viti stringere svitare bulloni stringere bulloni avvitare e svitare bulloni stringere e allentare bulloni girare i bulloni stringere viti ~~utensile da lavoro~~ aprire e chiudere bulloni

Nebulizer	mettere il profumo spruzzare profumo ~~essere profumati~~ ~~fare zuc zuc zuc~~	mettere il profumo spruzzare il profumo ~~contenere profumo~~ vaporizzare il profumo ~~avere un buon odore~~ erogare profumo ~~essere profumati~~ diffondere profumo	~~odorare~~ spruzzare profumo ~~contenere profumo~~ ~~profumare~~ emettere profumo erogare profumo nebulizzare profumo vaporizzare profumo diffondere profumo mettere il profumo ~~portaprofumo~~
Tube holder		fermare bloccare	bloccare tubi
Fork	mangiare	mangiare ~~prendere il cibo~~	~~prendere il cibo~~ mangiare ~~infilzare il cibo~~
Pocket glass	Bere ~~portare con sé~~ ~~portare fuori casa~~	Bere bere fuori casa ~~ridurre le dimensioni di un bicchiere~~ ~~portare con sé~~	Bere ~~occupare poco spazio~~ bere fuori casa ~~portare con sé~~ ~~piegare~~ ~~utilizzare in viaggio~~
Mouse	usare il computer comandare il computer cliccare giocare al computer lavorare al computer	~~usare il computer~~ muovere la freccia sullo schermo controllare il computer gestire un pc cliccare sullo schermo muovere il cursore comandare il pc ~~lavorare con il computer~~ selezionare sul pc comandare la freccetta mandare comandi guidare il cursore sul pc cliccare spostare il cursore	muovere il cursore spostare il cursore dirigere il cursore comandare il cursore del computer controllare il computer selezionare col puntatore cliccare ~~accedere alle cartelle del pc~~ ~~usare il computer~~ ~~interagire con il pc~~ ~~trasmettere il movimento della mano al computer~~ inviare comandi al pc dare istruzioni al pc puntare sul desktop ~~lavorare al pc~~ spostarsi sul desktop ~~collegare al computer~~ ~~gestire programmi del computer~~
Potato masher	schiacciare schiacciare le patate fare il purè	schiacciare schiacciare le patate fare il purè ~~passare le verdure~~	schiacciare le patate premere le patate ridurre in poltiglia le patate fare il purè tritare le patate schiacciare le verdure fare una purea di patate pressare le verdure comprimere le patate pressare le patate
Plunger	~~aggiustare il lavandino~~ pulire il lavandino pulire le tubature	sturare il lavandino pulire il bagno pulire il lavandino pulire i tubi liberare il wc liberare il lavandino sbloccare il lavandino sturare il wc	sturare il lavandino sturare le tubature sturare togliere ingorghi dal lavandino sbloccare la discesa dell'acqua stasare i sifoni

		pulire il wc liberare le tubature ~~attirare qualcosa~~ sturare le tubature	liberare il lavandino liberare i tubi disostruire il lavandino rimuovere intasamenti sturare gli scarichi sturare il wc sgorgare lo scarico del lavandino sbloccare lo scarico rimuovere ostruzioni sgorgare il lavandino ~~eliminare residui~~ sbloccare le otturazioni disostruire i tubi
Tube squeezer			spremere tubetti
Padlock	chiudere tenere chiuso chiudere cancelli	chiudere bene tenere chiuso chiudere chiudere il cancello ~~evitare furti~~ bloccare tenere al sicuro bloccare la serratura chiudere armadietti sigillare chiudere con sicurezza ~~proteggere qualcosa~~	chiudere assicurare la chiusura tenere al sicuro chiudere in sicurezza bloccare l'apertura ~~evitare un furto~~ sigillare bloccare la serratura ~~proteggere~~ tenere chiuso mantenere chiuso bloccare chiudere la serratura mettere in sicurezza ~~proteggere oggetti di proprietà~~
Screwdriver	~~aggiustare qualcosa~~ girare avvitare girare le viti aprire e chiudere le viti stringere svitare smontare e montare	fissare girare le viti avvitare e svitare le viti ~~aggiustare qualcosa~~ togliere e mettere le viti allentare o stringere le viti	avvitare e svitare le viti girare le viti allentare le viti stringere o rimuovere le viti
Earphone	ascoltare ascoltare canzoni ~~parlare al telefono~~ ~~metterlo all'orecchio~~	~~metterlo all'orecchio~~ ascoltare la musica ~~parlare al telefono~~	ascoltare la musica ~~parlare al telefono~~ ~~conversare~~ ~~connettere al cellulare~~ ascoltare ~~connettersi ad altri dispositivi~~
Bag shutter			chiudere sacchetti
Folding funnel	versare versare nelle bottiglie ~~salvare lo spazio~~	versare nelle bottiglie travasare versare liquidi versare l'acqua mettere nella bottiglia far passare un liquido	~~filtrare~~ travasare liquidi invasare facilitare l'inserimento dei liquidi nelle bottiglie versare liquidi nelle bottiglie imbottigliare far passare i liquidi in piccole fessure versare i liquidi in un contenitore più piccolo riempire una bottiglia ~~occupare poco spazio~~ convogliare i liquidi

Whistle	fischiare ~~soffiare forte~~ ~~giocare~~ ~~fermarsi~~	fischiare ~~richiamare~~ ~~suonare~~ ~~richiamare l'attenzione~~ ~~ampliare il fischio~~ ~~dare comandi~~ ~~emettere suoni~~ ~~far rumore~~	Fischiare ~~avvisare le persone~~ ~~dare l'inizio e la fine~~ ~~dare segnali~~ richiamare l'attenzione ~~emettere un suono~~ attirare l'attenzione ~~emettere suoni acuti~~ ~~arbitrare~~ produrre un fischio ~~dare inizio a una gara~~ ~~farsi sentire~~ ~~soffiare~~ ~~dirigere una partita~~ ~~fare allenamento~~ ~~richiamo sonoro~~ ~~segnalare qualcosa~~
Fruit peeler ring			rompere la buccia dell'arancia sbucciare le arance incidere buccia degli agrumi
Tie wrap	legare qualcosa ~~aggiustare qualcosa~~ fermare qualcosa	legare qualcosa legare insieme qualcosa mantenere insieme qualcosa sigillare ~~fare i torciglioni~~ fissare qualcosa fermare qualcosa stringere qualcosa legare i capelli ~~chiudere qualcosa~~ ~~fare pettinature~~ tenere unite delle cose	bloccare stringere qualcosa fissare oggetti legare in modo stretto ~~chiudere sacchetti~~ tenere insieme delle cose ~~chiudere qualcosa~~ fermare fissare fili stringere cavi bloccare cavi e fili sigillare oggetti ~~chiudere molto forte~~
Metronome	tenere il tempo dare il ritmo	~~fare tic tac~~ ~~suonare uno strumento~~ misurare il tempo seguire il ritmo tenere il tempo portare il tempo scandire il tempo tenere il ritmo	dare il tempo misurare il tempo scandire il tempo tenere il tempo definire il ritmo ~~accordare gli strumenti~~ segnare il tempo portare il tempo contare il tempo battere il tempo indicare un ritmo battere il ritmo giusto tenere il ritmo
Cotton swab	pulire le orecchie ~~mettere nelle orecchie~~	pulire le orecchie togliere lo sporco dalle orecchie igienizzare le orecchie igiene personale	pulire le orecchie igienizzare le orecchie pulire il canale uditivo/igiene auricolare pulire il padiglione auricolare lavare le orecchie pulire piccole zone pulire di cavità ~~rovinare le orecchie~~
Fruit cutter			affettare la frutta dividere il kiwi tagliare l'uovo in parti uguali

			tagliare il kiwi
Egg scissors			tagliare il guscio dell'uovo dividere l'uovo sodo aprire l'uovo sodo
Bottle	bere	~~bere~~ ~~portare a scuola~~ ~~portare in giro~~ contenere acqua contenere liquidi conservare bevande mettere bevande	~~bere~~ ~~riempire l'acqua~~ contenere liquidi contenere acqua conservare liquidi ~~portare l'acqua in giro~~ ~~portare acqua con sé~~ ~~dissetarsi~~ ~~abbeverarsi~~ ~~trasportare liquidi~~
Sieve	mettere lo zucchero mettere la farina spolverare	muovere la farina spargere lo zucchero ~~filtrare lo zucchero~~ far uscire lo zucchero setacciare togliere i grumi spolverare la farina ~~dosare la farina~~ setacciare la farina mettere lo zucchero a velo	mettere lo zucchero a velo setacciare la farina spargere lo zucchero a velo setacciare spolverare lo zucchero a velo diffondere lo zucchero a velo ~~filtrare la farina~~ distribuire ingredienti in polvere distribuire zucchero a velo setacciare zucchero a velo spargere in modo uniforme dividere materiali polverosi
Clothespin	appendere i panni stendere i panni mettere i panni fuori non far cadere i panni far asciugare i panni tenere i panni al filo mantenere i panni stesi ~~legare i capelli~~	appendere i panni stendere i panni stendere il bucato fermare i vestiti tenere fermi i panni fissare i vestiti tenere i vestiti appendere qualcosa stendere la biancheria ~~chiudere i sacchetti~~ appendere la biancheria mantenere i panni stringere qualcosa pinzare i panni appendere il bucato	stendere i panni mantenere fermi gli oggetti stendere i vestiti appendere i panni mantenere gli indumenti stesi fermare i panni stesi appendere i vestiti sostenere i panni stesi fermare il bucato appendere il bucato fissare la biancheria pinzare indumenti

Tap	~~lavare le mani~~ aprire l'acqua aprire e chiudere l'acqua ~~bere~~ far uscire l'acqua ~~lavare i piatti~~	~~lavare le mani~~ far uscire l'acqua aprire e chiudere l'acqua far scendere l'acqua ~~lavare i piatti~~ miscelare l'acqua aprire l'acqua far scorrere l'acqua comandare il getto dell'acqua erogare l'acqua aprire il lavandino versare acqua	versare acqua ~~lavare~~ ~~lavare le mani~~ far uscire l'acqua ~~regolare il flusso dell'acqua~~ aprire e chiudere l'acqua azionare l'acqua ~~regolare la temperatura dell'acqua~~ erogare acqua far scorrere l'acqua ~~scegliere acqua calda o fredda~~ ~~miscelare l'acqua~~

Note. ~~Function expressions~~ have been considered different functions.

APPENDIX B

Table 3. Classification of objects in high, medium, and low Familiarity for each Dutch age group based on the results of MDS. For each object, the weight on Dimension 1 is specified.

	All age groups	Dim 1	Preschoolers	Dim 1	Adults	Dim 1
High Familiarity	Fork	-,823	Fork	1,028	Sponge	-,647
	Bottle	-,823	Bottle	1,028	Nebulizer	-,647
	Clothespin	-,823	Clothespin	1,028	Fork	-,647
	Tap	-,823	Tap	1,028	Mouse	-,647
	Sponge	-,807	Sponge	,996	Plunger	-,647
	Whistle	-,755	Whistle	,891	Padlock	-,647
	Screwdriver	-,731	Screwdriver	,843	Screwdriver	-,647
	Mouse	-,654	Mouse	,664	Whistle	-,647
	Padlock	-,567	Closable glass	,540	Cotton swab	-,647
	Cotton swab	-,531	Wrench	,461	Bottle	-,647
Medium Familiarity	Wrench	-,513	Padlock	,376	Clothespin	-,647
	Plunger	-,414	Cotton swab	,287	Tap	-,647
	Nebulizer	-,349	Plunger	,079	Wrench	-,538
	Closable glass	-,230	Earphone	-,047	earphone	-,380
	earphone	-,187	Nebulizer	-,145	Binder clip	-,290
	Potato masher	-,038	Potato masher	-,259	Potato masher	-,186
	Binder clip	,014	Hairpin	-,366	Closable glass	-,061
	Hairpin	,108	Tie wrap	-,462	Hairpin	-,007
	Tie wrap	,239	Binder clip	-,609	Tie wrap	,152
	Metronome	,392	T. book holder	-,669	Metronome	,322
Low Familiarity	Folding funnel	,574	Nutcracker	-,669	Folding funnel	,557
	Fruit cutter	,682	Tube holder	-,669	Fruit cutter	,693
	Sieve	,747	Tube squeezer	-,669	Sieve	,774
	Tube holder	,806	Bag shutter	-,669	Tube holder	,844
	Bag shutter	,834	Folding funnel	-,669	Bag shutter	,879
	T. book holder	,888	Peeler ring	-,669	T. book holder	,945
	Nutcracker	,916	Metronome	-,669	Nutcracker	,979
	Eggs scissors	,932	Fruit cutter	-,669	Egg scissors	,998
	Tube squeezer	,963	Eggs scissors	-,669	Tube squeezer	1,037
	Peeler ring	,972	Sieve	-,669	Peeler ring	1,049

Table 4. Classification of objects in high, medium, and low Frequency of Personal Use for each Dutch age group based on the results of MDS. For each object, the weight on Dimension 1 is specified.

	All age groups	Dim 1	Preschoolers	Dim 1	Adults	Dim 1
High Frequency of Personal Use	Tap	1,362	Tap	1,546	Fork	1,283
	Fork	1,331	Fork	1,445	Tap	1,274
	Bottle	1,176	Bottle	1,151	Bottle	1,177
	Cotton swab	,900	Sponge	,738	Mouse	,992
	Mouse	,844	Whistle	,664	Cotton swab	,939
	Sponge	,715	Clothespin	,529	Sponge	,751
	Clothespin	,622	Screwdriver	,453	Clothespin	,675
	Padlock	,525	Padlock	,368	Padlock	,576
	Whistle	,405	Cotton swab	,345	Whistle	,395
	Screwdriver	,333	Closable glass	,301	Screwdriver	,348
Medium Frequency of Personal Use	Nebulizer	,205	Sieve	,247	Nebulizer	,231
	Wrench	,053	Tube squeezer	,100	Wrench	,037
	Binder clip	-,011	Wrench	,022	Potato masher	,031
	Potato masher	-,031	Mouse	-,058	Binder clip	-,084
	Plunger	-,150	Binder clip	-,083	Earphone	-,087
	Hairpin	-,182	Peeler ring	-,151	Plunger	-,226
	earphone	-,208	Plunger	-,208	Hairpin	-,253
	Tie wrap	-,293	Hairpin	-,293	Tie wrap	-,293
	Sieve	-,351	Nebulizer	-,338	Metronome	-,396
	Metronome	-,436	Folding funnel	-,399	Sieve	-,439
Low Frequency of Personal Use	Tube squeezer	-,517	Fruit cutter	-,443	Tube squeezer	-,572
	Closable glass	-,568	Egg scissors	-,513	Peeler ring	-,612
	Peeler ring	-,599	Potato masher	-,538	Closable glass	-,636
	Folding funnel	-,648	Earphone	-,580	Egg scissors	-,672
	Egg scissors	-,680	Bag shutter	-,650	Folding funnel	-,698
	T. book holder	-,717	Nutcracker	-,652	T. book holder	-,727
	Nutcracker	-,726	Tie wrap	-,685	Nutcracker	-,741
	Fruit cutter	-,759	Metronome	-,704	Tube holder	-,752
	Bag shutter	-,793	T. book holder	-,787	Bag shutter	-,759
	Tube holder	-,803	Tube holder	-,827	Fruit cutter	-,764

Table 5. Classification of objects in high, medium, and low Frequency of Observed Use for each Dutch age group based on the results of MDS. For each object, the weight on Dimension 1 is specified.

	All age groups	Dim 1	Preschoolers	Dim 1	Adults	Dim 1
High Frequency of Observed Use	Fork	1,193	Tap	1,243	Fork	1,177
	Tap	1,173	Fork	1,199	Tap	1,144
	Bottle	1,083	Bottle	1,025	Bottle	1,102
	Mouse	,960	Mouse	,905	Mouse	,979
	Clothespin	,811	Sponge	,792	Clothespin	,818
	Sponge	,761	Clothespin	,742	Sponge	,757
	Cotton swab	,624	Screwdriver	,664	Cotton swab	,655
	Screwdriver	,560	Cotton swab	,508	Whistle	,577
	Whistle	,514	Whistle	,420	Padlock	,523
	Padlock	,447	Sieve	,385	Screwdriver	,466
Medium Frequency of Observed Use	Wrench	,283	Padlock	,274	Wrench	,287
	Nebulizer	,167	Wrench	,216	Nebulizer	,210
	Plunger	,086	Tube squeezer	,083	Earphone	,138
	Potato masher	,028	Potato masher	,045	Plunger	,056
	Earphone	-,013	Plunger	-,058	Binder clip	-,033
	Binder clip	-,094	Closable glass	-,103	Potato masher	-,070
	Hairpin	-,196	Hairpin	-,244	Hairpin	-,191
	Sieve	-,269	Binder clip	-,272	Metronome	-,240
	Metronome	-,337	Nebulizer	-,363	Tie wrap	-,325
	Tie wrap	-,384	Tie wrap	-,428	Sieve	-,430
Low Frequency of Observed Use	Tube squeezer	-,492	Peeler ring	-,486	Tube squeezer	-,549
	Closable glass	-,599	Earphone	-,525	Closable glass	-,656
	Peeler ring	-,662	Folding funnel	-,589	Peeler ring	-,699
	Nutcracker	-,715	Fruit cutter	-,653	Nutcracker	-,741
	Folding funnel	-,745	T. book holder	-,679	Egg scissors	-,772
	Egg scissors	-,786	Egg scissors	-,758	Folding funnel	-,799
	T. book holder	-,803	Bag shutter	-,778	T. book holder	-,821
	Bag shutter	-,838	Nutcracker	-,799	Bag shutter	-,836
	Fruit cutter	-,859	Metronome	-,834	Fruit cutter	-,864
	Tube holder	-,900	Tube holder	-,932	Tube holder	-,866

Table 6. Classification of objects in high, medium, and low Familiarity for each Croatian age group based on the results of MDS. For each object, the weight on Dimension 1 is specified.

	All age groups	Dim 1	Preschoolers	Dim 1	Schoolers	Dim1	Adults	Dim 1
High Familiarity	Sponge	-,710	Sponge	,989	Sponge	-,721	Sponge	-,656
	Fork	-,710	Fork	,989	Fork	-,721	Fork	-,656
	Mouse	-,710	Mouse	,989	Mouse	-,721	Mouse	-,656
	Bottle	-,710	Bottle	,989	Padlock	-,721	Padlock	-,656
	Clothespin	-,710	Clothespin	,989	Bottle	-,721	Cotton swab	-,656
	Tap	-,710	Tap	,989	Clothespin	-,721	Bottle	-,656
	Padlock	-,666	Whistle	,750	Tap	-,721	Clothespin	-,656
	Whistle	-,645	Padlock	,668	Nebulizer	-,689	Tap	-,656
	Cotton swab	-,628	Screwdriver	,634	Cotton swab	-,663	Whistle	-,633
	Nebulizer	-,604	Nebulizer	,457	Screwdriver	-,656	Nebulizer	-,605
Medium Familiarity	Screwdriver	-,572	Cotton swab	,383	Whistle	-,592	Plunger	-,597
	Plunger	-,528	Wrench	,226	Plunger	-,537	Screwdriver	-,537
	Wrench	-,475	Plunger	,132	Wrench	-,445	Wrench	-,535
	Binder clip	-,323	Binder clip	,054	Binder clip	-,372	Earphone	-,343
	Earphone	-,252	Closable glass	-,153	Earphone	-,235	Closable glass	-,300
	Closable glass	-,181	Earphone	-,174	Closable glass	-,088	Binder clip	-,228
	Potato masher	-,038	Hairpin	-,353	Potato masher	,013	Potato masher	-,089
	Hairpin	,064	Potato masher	-,399	Hairpin	,168	Hairpin	-,008
	Metronome	,242	Bag shutter	-,525	Folding funnel	,304	Tie wrap	,153
	Tie wrap	,308	Egg scissors	-,578	Metronome	,411	Metronome	,247
Low Familiarity	Folding funnel	,401	T. book holder	-,706	Tie wrap	,513	Folding funnel	,379
	Sieve	,637	Nutcracker	-,706	Sieve	,670	Sieve	,622
	Tube holder	,788	Tube holder	-,706	Fruit cutter	,807	Tube holder	,778
	Egg scissors	,865	Tube squeezer	-,706	Egg scissors	,862	Egg scissors	,880
	Fruit cutter	,904	Folding funnel	-,706	Tube squeezer	,885	Nutcracker	,928
	Nutcracker	,936	Peeler ring	-,706	Tube holder	,906	Fruit cutter	,956
	Tube squeezer	,973	Tie wrap	-,706	T. book holder	,947	Tube squeezer	1,006
	T. book holder	1,001	Metronome	-,706	Nutcracker	,947	Peeler ring	1,029
	Peeler ring	1,017	Fruit cutter	-,706	Bag shutter	,947	T. book holder	1,061
	Bag shutter	1,036	Sieve	-,706	Peeler ring	,947	Bag shutter	1,080

Table 7. Classification of objects in high, medium, and low Frequency of Personal Use for each Croatian age group based on the results of MDS. For each object, the weight on Dimension 1 is specified.

	All age groups	Dim 1	Preschoolers	Dim 1	Schoolers	Dim 1	Adults	Dim 1
High Frequency of Personal Use	Tap	1,217	Sponge	,989	Fork	1,272	Tap	1,174
	Fork	1,200	Fork	,989	Tap	1,246	Fork	1,159
	Bottle	1,110	Mouse	,989	Bottle	1,172	Bottle	1,086
	Cotton swab	1,004	Bottle	,989	Cotton swab	1,045	Sponge	1,039
	Mouse	,936	Clothespin	,989	Mouse	,830	Mouse	,992
	Sponge	,879	Tap	,989	Clothespin	,641	Cotton swab	,916
	Clothespin	,741	Whistle	,750	Sponge	,578	Clothespin	,811
	Nebulizer	,514	Padlock	,668	Nebulizer	,520	Nebulizer	,518
	Padlock	,348	Screwdriver	,634	Earphone	,429	Padlock	,382
	Screwdriver	,294	Nebulizer	,457	Sieve	,345	Screwdriver	,315
Medium Frequency of Personal Use	Whistle	,167	Cotton swab	,383	Whistle	,228	Whistle	,130
	Sieve	,141	Wrench	,226	Screwdriver	,169	Binder clip	,089
	Binder clip	,026	Plunger	,132	Padlock	,112	Potato masher	,027
	earphone	-,002	Binder clip	,054	Closable glass	,037	Wrench	-,046
	Wrench	-,114	Closable glass	-,153	Binder clip	-,111	Sieve	-,073
	Potato masher	-,153	Earphone	-,174	Wrench	-,192	Plunger	-,162
	Plunger	-,243	Hairpin	-,353	Folding funnel	-,254	Hairpin	-,221
	Hairpin	-,296	Potato masher	-,399	Potato masher	-,322	Earphone	-,271
	Tie wrap	-,352	Bag shutter	-,525	Tie wrap	-,398	Tie wrap	-,339
	Closable glass	-,399	Egg scissors	-,578	Plunger	-,451	Folding funnel	-,427
Low Frequency of Personal Use	Folding funnel	-,456	T. book holder	-,706	Tube squeezer	-,487	Closable glass	-,478
	Metronome	-,568	Nutcracker	-,706	Metronome	-,536	Metronome	-,574
	Tube squeezer	-,632	Tube holder	-,706	Hairpin	-,608	Tube squeezer	-,660
	Peeler ring	-,694	Tube squeezer	-,706	Fruit cutter	-,654	Tube holder	-,716
	Fruit cutter	-,722	Folding funnel	-,706	Peeler ring	-,690	Peeler ring	-,729
	Tube holder	-,741	Peeler ring	-,706	Egg scissors	-,718	Bag shutter	-,755
	Bag shutter	-,779	Tie wrap	-,706	Tube holder	-,753	Fruit cutter	-,772
	Nutcracker	-,791	Metronome	-,706	Nutcracker	-,774	Nutcracker	-,791
	Egg scissors	-,808	Fruit cutter	-,706	T. book holder	-,811	T. book holder	-,801
	T. book holder	-,824	Sieve	-,706	Bag shutter	-,863	Egg scissors	-,823

Table 8. Classification of objects in high, medium, and low Frequency of Observed Use for each Croatian age group based on the results of MDS. For each object, the weight on Dimension 1 is specified.

	All age groups	Dim 1	Preschoolers	Dim 1	Schoolers	Dim 1	Adults	Dim 1
High Frequency of Personal Use	Tap	1,088	Tap	1,243	Tap	1,086	Fork	1,081
	Fork	1,068	Mouse	1,164	Fork	1,064	Tap	1,055
	Bottle	1,016	Clothespin	1,042	Bottle	1,001	Bottle	1,025
	Mouse	,959	Sieve	1,004	Sponge	,896	Sponge	,981
	Sponge	,927	Sponge	,896	Mouse	,865	Mouse	,953
	Clothespin	,790	Fork	,793	Cotton swab	,779	Clothespin	,804
	Cotton swab	,725	Cotton swab	,677	Clothespin	,707	Cotton swab	,717
	Screwdriver	,549	Bottle	,624	Screwdriver	,549	Screwdriver	,558
	Nebulizer	,474	Nebulizer	,431	Nebulizer	,516	Padlock	,434
	Padlock	,362	Screwdriver	,303	Whistle	,376	Nebulizer	,413
Medium Frequency of Personal Use	Whistle	,325	Closable glass	,271	Sieve	,355	Whistle	,329
	Wrench	,246	Plunger	,011	Padlock	,253	Wrench	,268
	Earphone	,189	Whistle	-,039	Earphone	,209	Earphone	,184
	Sieve	,084	Tube squeezer	-,065	Wrench	,129	Binder clip	,040
	Binder clip	-,019	Binder clip	-,109	Closable glass	-,010	Potato masher	,007
	Potato masher	-,065	Earphone	-,200	Potato masher	-,083	Plunger	-,080
	Plunger	-,152	Padlock	-,246	Binder clip	-,148	Sieve	-,125
	Hairpin	-,227	Wrench	-,317	Plunger	-,251	Hairpin	-,196
	Tie wrap	-,347	Peeler ring	-,354	Folding funnel	-,335	Tie wrap	-,331
	Metronome	-,411	Metronome	-,354	Hairpin	-,393	Metronome	-,401
Low Frequency of Personal Use	Closable glass	-,453	Bag shutter	-,428	Tie wrap	-,478	Folding funnel	-,496
	Folding funnel	-,520	T. book holder	-,524	Metronome	-,548	Closable glass	-,547
	Tube squeezer	-,665	Hairpin	-,524	Tube squeezer	-,651	Tube squeezer	-,683
	Peeler ring	-,747	Tie wrap	-,642	Peeler ring	-,714	Peeler ring	-,774
	Fruit cutter	-,789	Fruit cutter	-,642	Fruit cutter	-,756	Nutcracker	-,817
	Bag shutter	-,832	Folding funnel	-,688	Egg scissors	-,819	Fruit cutter	-,828
	Nutcracker	-,856	Egg scissors	-,692	Bag shutter	-,864	Tube holder	-,854
	Tube holder	-,885	Nutcracker	-,768	Nutcracker	-,875	Bag shutter	-,885
	Egg scissors	-,907	Potato masher	-,836	Tube holder	-,914	Egg scissors	-,910
	T. book holder	-,928	Tube holder	-1,030	T. book holder	-,947	T. book holder	-,921

APPENDIX C

Figure 1. Examples of manipulation of familiar objects by children, preadolescents, and adults

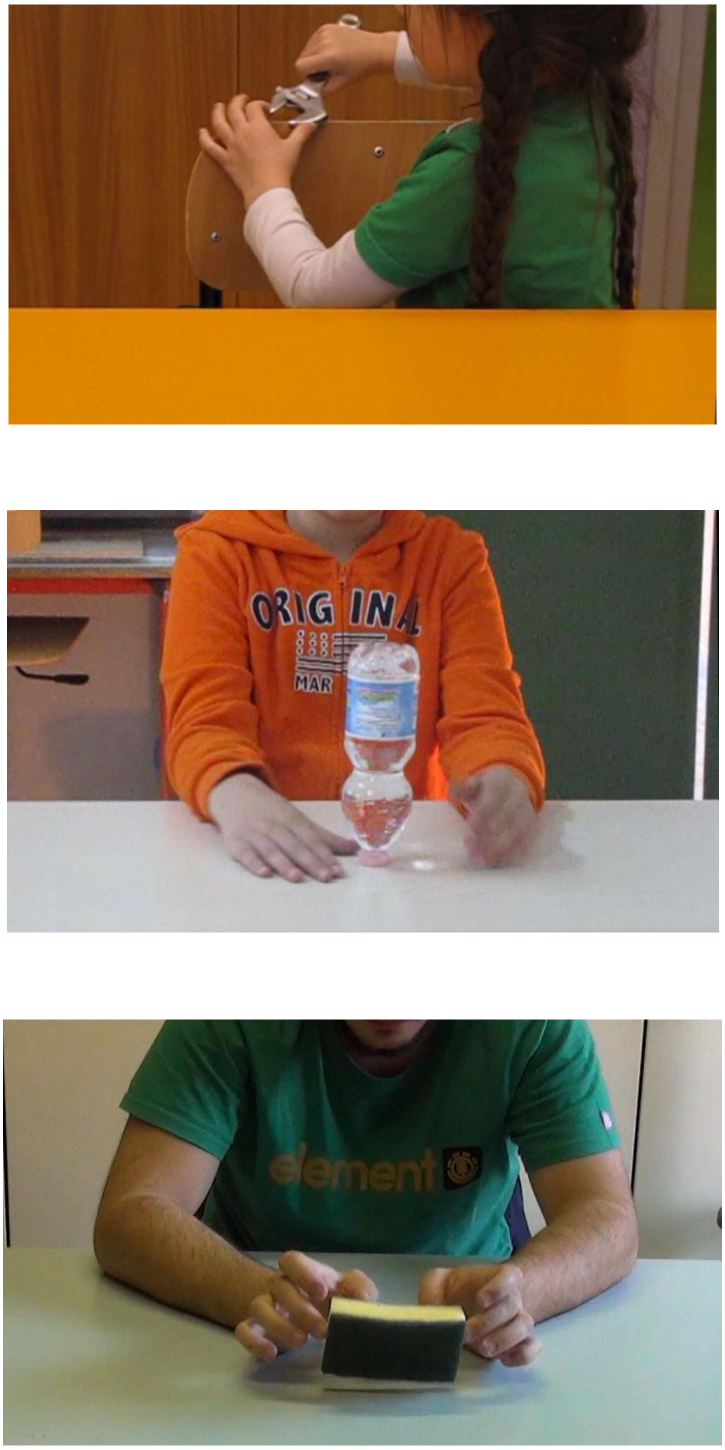
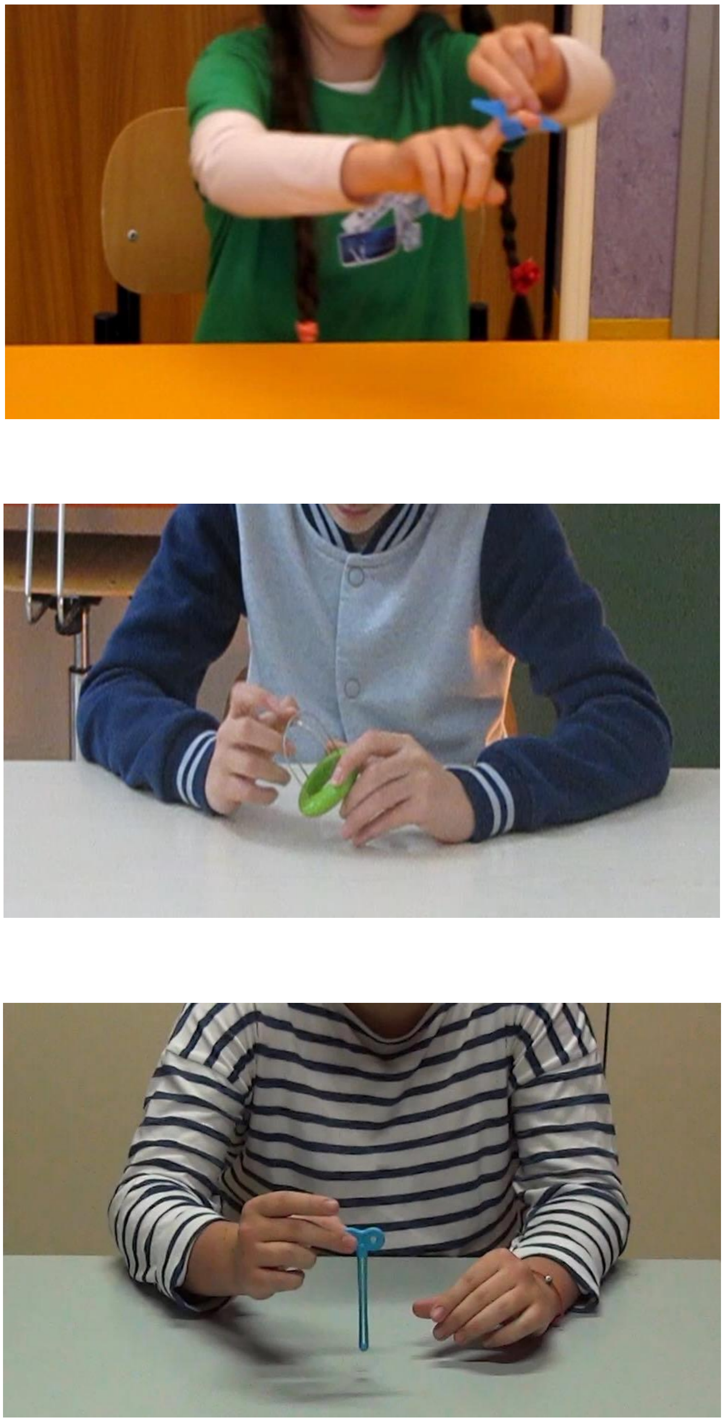


Figure 2. Examples of manipulation of non-familiar objects by children, preadolescents, and adults



APPENDIX D

Table 1. List of more and less familiar stimuli used into the experiment.

More familiar objects	**Less familiar objects**
Sponge	Thumb book holder
Wrench	Tube holder
Cotton swab	Tube squeezer
Clothespin	Bag shutter
Bottle	Fruit cutter
Tap	Egg scissors
Binder clip	Sieve
Hairpin	Folding funnel
Tie wrap	Metronome