Language and Bilingual Cognition

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Psychology Press
Taylor & Francis Group
NEW YORK AND HOVE

Published in 2011
by Psychology Press
270 Madison Avenue
New York, NY 10016
www.psypress.com

Published in Great Britain
by Psychology Press
27 Church Road
Hove, East Sussex BN3 2FA

Psychology Press is an imprint of the Taylor & Francis Group, an Informa business

Typeset in Times by
RefineCatch Limited, Bungay, Suffolk
Printed in the USA by
Sheridan Books, Inc. on acid-free paper
Cover design by Aubergine Creative Design

10 9 8 7 6 5 4 3 2 1

Library of Congress Cataloging in Publication Data
A catalog record for this book is available from the Library of Congress.

ISBN: 978–1–84872–924–7

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6 Tools for thinking

Barbara Tversky

For some reason the idea that the language one speaks affects the way one thinks, the Whorf or Sapir-Whorf hypothesis (e.g., Sapir, 1921; Whorf, 1956), is repugnant to some and stirring to others. Perhaps because of the passion it arouses, it produces clever experiments. Take speakers of Guugu Yimithirr, a language that uses only the cardinal directions to locate things in space, and drive them around every which way, and ask them to point home. They do so remarkably accurately. Take speakers of Dutch, a language that uses egocentric relations as well as cardinal directions to locate things in space and do the same—they point randomly (e.g., Levinson, 1996, 2003). Ask native German speakers to describe objects like a *bridge* in English. Some use terms like *elegant*, *fragile*, or *slender*. Ask the same of native Spanish speakers. Some use terms like *strong*, *sturdy*, or *towering* (Boroditsky, Schmidt, & Phillips, 2003). Why? In German, the word for *bridge* is feminine, whereas in Spanish it is masculine. Ask people who speak languages that refer to objects like boxes as units of substance, similar to 'pieces of cardboard', whether a plastic box or a piece of cardboard goes better with a cardboard box. They tend to group by stuff; they pick the piece of cardboard as often as the plastic box. In contrast, speakers of languages like English that individuate objects tend to group by kind; they pick the plastic box (e.g., Imai & Gentner, 1997; Lucy, 1992; Lucy & Gaskins, 2001, 2003). Effects of language have been shown for time (e.g., Boroditsky, 2001) as well as space, for color and shape as well as for substance/object (e.g., Roberson, Davidoff, & Shapiro, 2002; Roberson, Davies, & Davidoff, 2000). As for the effects of language on spatial cognition, the effects of language on perception of color, objects, and substance have been challenged. Sometimes the challenge is specific, that alternative explanations seem more plausible for the case at hand (e.g., Li, Dunham, & Carey, 2008), but sometimes the challenge is general, to the very idea that the language one speaks can affect the way one thinks (e.g., Li & Gleitman, 2002; but see Levinson, Kita, Haun, & Rasch, 2002).

Perhaps a broader perspective is needed. What kinds of things do affect thought? And how do they affect thought? Let's start close to controversy, with effects of language within a language. There are simply more things

and features of things, and relations among things and relations among their features, and actions of things and relations among their actions and their features in the world, than there are words. Words select among that multitude of features, acting as pointers or filters. Word associations to names of objects are more stereotyped and focused than word associations to pictures of objects, presumably because they are less affected by the visual properties inevitably apparent in pictures of objects or objects themselves (Deno, Johnson, & Jenkins, 1968; Otto, 1962; Wicker, 1970; Winn, 1976).

Language can do more than select features. Language can favor some kinds of features over other kinds of features. Significantly, using language can focus attention on features such as function not readily available in perception; that is, from momentary views of static objects. For example, when people compared two pictures of bodies with a part highlighted to verify whether the same part was highlighted in both, reaction times were fastest for parts that were perceptually salient; specifically, high in contour distinctiveness. However, when people compared a name of a body part to a picture of a body with a part highlighted, reaction times were fastest for parts that were functionally significant, as rated independently (Morrison & Tversky, 2005). Functional significance is not readily apparent from seeing bodies; it depends on knowing what different body parts do, even ones hidden inside the body, and how what they do affects one's life. Words for things arouse abstract features of the things more than the things themselves. A related phenomenon occurs when people provide the words themselves, by giving play-by-play descriptions for ongoing actions, simple everyday activities such as making beds and doing dishes. Those who described the activities as they watched them organized them more hierarchically than those who simply watched (Zacks, Tversky, & Iyer, 2001). The descriptions give clues to why describing had the effect of organizing perception. The descriptions were primarily of completed goals and subgoals, completed actions on objects, such as *putting on the bottom sheet* or *rinsing the plate*. The act of describing ongoing action (a longer discussion) focused attention on completion of actions. Since action completions are hierarchically organized—*smoothing the sheet* is the last part of *putting on the sheet*, which is in turn a middle part of *making a bed*—describing in language served to increase hierarchical organization of the perception of ongoing action.

Because language can select certain features at the expense of others, it can also be detrimental. It may focus on the wrong features for the task. Faces, notoriously difficult to describe, provide an example. Describing faces while viewing them can make them more difficult to recognize later (Schooler, 1997). Describing appears to focus attention on features that are easy to describe. Those features, such as eye color or hair texture, do not seem to be useful in discriminating old faces from new ones. At the same time, describing takes attention away from features of faces such as configurations of features that are hard to describe but central to recognition.

Language can go beyond selecting certain features of things and ignoring others. Language can signal that something belongs to a category. Being in a category has consequences for relations to other things within the category as well as for relations of things in the category to things in other categories. This is apparent in performance of children in matching tasks. Children are shown a picture of a target object and asked to select which of two pictures of other objects goes better with, or is another example of, or is the same as, the target object. When children are shown a picture of a bee, for example, and asked to find what 'goes better' with the bee, an ant or a flower, they pick the flower. They pick the flower even when asked to 'find me the same kind of thing as this'. However, when they are shown the picture of the bee and asked to find another *sud*, they are more likely to pick the ant, and less likely to pick the thematically related object, the flower (Markman & Hutchinson, 1984). Using a name, a word, a label, even if a nonsense word, is what matters. Languages typically use names or labels to refer to categories of things that share features, such as 'tiny, wiry creatures with heads and legs that fly or crawl', which we call *insects*, but languages typically don't use names to refer to themes that relate different objects, such as 'bees extract nectar from flowers'. The label seems to signal to the child that the bee belongs to a category and to focus on the features shared by the category rather than on interactions of the bee with other things. Language can call attention to relations between categories as well as to category membership. Providing preschoolers with words for spatial relations, such as *top*, *middle*, or *bottom* helps them solve a spatial analogy problem in which they are asked to place a card in the same relative position as a previous one (Lowenstein & Gentner, 2005).

Note that many of the effects of language on thought are not effects of words per se. The attribution of feminine features to bridges by German speakers and masculine features to bridges by Spanish speakers described earlier is an effect of grammatical gender, not of specific words (Boroditsky et al., 2003). Simply the way words are arbitrarily ordered affects thought. When a person is described with a list of varied personality attributes, some positive, some negative, the first descriptor carries the greatest weight in later ratings of likability (Anderson & Hubert, 1963). The weight people give to the descriptors in estimating likability declines with the serial order of the descriptor.

Many of these effects of language within a language go beyond 'thinking for speaking', the analysis Slobin (1996) proposed for Whorfian effects. Language used by others affects the thought of listeners as well as speakers. As noted, children are more likely to group taxonomically instead of thematically when they hear a pseudo category label (Markman & Hutchinson, 1984), and adults are more likely to attend to functional features of body parts when they are named than when they are presented

visually (Morrison & Tversky, 2005). The case that turned insurance investigator Whorf into a linguist is yet another example (Whorf, 1956). He investigated fires that were caused by people who were careless with matches around oil barrels because the barrels had been described as 'empty'.

Equally important, language appears to have longer-term off-line effects, encouraging people to attend to certain things, aspects, distinctions, and relations in the world and instilling associations to things, aspects, distinctions, and relations not directly given in perception. The ability to maintain orientation in space by speakers of a language that locates things in space using an absolute (cardinal directions) system is one example (Levinson, 2003). Another example comes from research within a language. A longitudinal study of language and cognitive development found that toddlers who heard and used more spatial language later performed a variety of spatial tasks better, specifically mental rotation, block designs, and spatial analogies (Levine, Huttenlocher, Gunderson, Rowe, & Pruden, 2009). If language biases thought within a language, then it is likely to do so across languages as well. Many of the mechanisms are similar, for example focusing attention on some aspects of things and not others.

Language is not unitary; it has many communicative strands, delicately interwoven. Yet other aspects of language affect thinking. Gesture is one of them. One's own gestures aid thought; sitting on the hands interferes with finding words (e.g., Krauss, Chen, & Gottesman, 2000). Others' gestures aid thought: Teachers' gestures help students learn math (e.g., Singer & Goldin-Meadow, 2005; Valenzano, Alibali, & Klatzky, 2003). Language can be written as well as spoken. The direction of reading and writing seems to be a chance and arbitrary convention, in that many languages are written left to right and many others are written right to left. Nevertheless, writing direction has dramatic effects on thought. Time is thought to go from left to right by speakers of languages that are written and read from left to right, and to go from right to left by speakers of languages written from right to left (e.g., Santiago, Román, Ouellet, Rodríguez, & Pérez-Azor, 2010; Tversky, Kugelmass, & Winter, 1991). A person depicted on the left is perceived as more agentive than one on the right for left–right languages but the opposite for right–left languages (Chatterjee, 2001). Action from left to right is perceived as stronger than right to left action by readers of left-to-right languages, but the reverse is true for readers of right-to-left languages (Maass, Pagani, & Berta, 2007). Aesthetic judgments (Chokron & De Agostini, 2000) and interpretation of facial expressions (Vaid & Singh, 1989) correspond to writing direction. Even more purely perceptual processing like apparent motion (Morikawa & McBeath, 1982) and perceptual exploration (Nachshon, 1985) are affected by reading order.

Language is a cognitive tool, one of many designed to expand the mind and foster the communication and coordination on which human society rests (e.g., Norman, 1993; Tversky, 2001). Like other cognitive tools—our bodies, pencil and paper, calculators, abaci, maps, graphs, design sketches, even the environment around us—language can help (or hinder) thought. Language encodes, encapsulates, emphasizes, summarizes, organizes, and transforms certain meanings and relations and not others. Language can serve communication, it can direct our own thoughts and actions, it can direct the thoughts and actions of others. Frequently, what language encodes and emphasizes is useful, but on occasion what it ignores might have been useful as well, true of any tuned and adaptive filtering or processing mechanism. Focusing, filtering, reducing, and transforming information has benefits and costs, depending on the task.

Thought is multifaceted, as are the interrelations of thought and the cognitive tools that serve it. Counting and arithmetic provide examples of the rich interactions between tools and thought. People who speak languages that have count-words solve certain problems better than people who speak languages that lack count-words (e.g., Frank, Everett, Fedorenko, & Gibson, 2008; Gordon, 2004). Some numerical competence—for example, estimating which of two quantities is larger—is possible without the training in counting that number words enable. People speaking languages without count-words can use one-to-one correspondence to compare two quantities when the quantities are spatially aligned in parallel. However, training in counting with number words augments this capacity, so that determining one-to-one correspondence for spatially disparate displays is easy for those speaking languages with count-words, but those speaking languages without count-words make errors. Note, however, the important role that actions, pointing and moving, have in learning to count and in determining one-to-one correspondences. Later, counting with the eyes can often substitute for counting with the fingers. Count-words allow inspecting and summing each display separately and using the final number as a memory aid for the entire array to compare arrays. Even the length of the words used to count makes a difference. Working memory capacity depends on number of syllables, so it is greater for shorter words with fewer syllables than for words with many syllables. As a consequence, speakers of languages whose count-words have fewer syllables, like Chinese, have longer number memory spans than speakers of languages whose count-words have many syllables, like Welsh (Baddeley & Hitch, 1974; Chen & Stevenson, 1988). Doing multiplication is easier with Arabic numerals than with Roman numerals (Zhang & Norman, 1995); try 36 times 9 versus XXXVI times IX. Doing multiplication with paper and pencil is easier than doing it in the mind. Training in arithmetic using an abacus alters the way children do mental arithmetic and the ways they think about numbers (Stigler, 1983). Both words for counting and devices for arithmetic are cognitive tools, and each tool, language and device, affects thought.

Many external cognitive tools affect thought in many different ways. Using an abacus is one example. Even the simple tool of pencil and paper affects thought. In many cases, marks on paper, diagrams or sketches, aid thinking, from to-do lists to computing square roots to designing buildings (e.g., Goldschmidt, 1994; Schon, 1983; Suwa & Tversky, 1997). However, just as for language, sketches and diagrams can bias thinking, not always for the best. Students checking diagrams of information systems, connections among computers, servers, clients, and the like, tend to scan them in reading order, from left to right. When many components need to be checked, students often neglect checking the later ones, leading to systematic errors (Corter, Rho, Zahner, Nickerson, & Tversky, 2009; Nickerson, Corter, Tversky, Zahner, & Rho, 2008). People tend to interpret lines on paper as connections, even as physical routes (Tversky, 2001), so that many students interpret lines in diagrams of components of information systems as routes through the system, and think that information must pass through all the intervening components to get from the leftmost to the rightmost component, an inference that can be erroneous (Corter et al., 2009; Nickerson et al., 2008).

The general claim should be clear by now. Language is one of many cognitive tools for thinking, a toolbox that also includes gestures, diagrams, training in a multitude of skills, like counting and arithmetic, and more. Each of these can affect thinking in diverse ways, but not necessarily. Cognitive tools, and specifically language, don't always affect thought. For example, languages differ widely in the dominant ordering of subjects, verbs, and objects. However, when asked to explain how to perform a variety of actions on objects using only gestures, speakers of languages with many different syntactic orders nevertheless ordered their gestures identically, subject–object–verb (Goldin-Meadow, So, Ozyurek, & Mylander, 2008).

If thought can be affected by so many different cognitive tools, why wouldn't the language one speaks be among those cognitive tools, given the multiplicity of ways that language is used and the multiplicity of ways that different languages cut up the world, spatially, temporally, causally, emotionally, and more? The evidence presented here, a small fraction of that available, illustrates only few of those multiple ways. If so, why does the very idea that the language one speaks affects how one thinks arouse so much resistance? Of course, challenging ideas is the usual business of science: proposing alternative hypotheses and finding evidence supporting them. However, some seem to fear that the Whorf hypothesis implies the frightening thought that speakers of different languages are doomed to never understand one another. To which one could point out that speakers of the same language, even within the same family, sometimes appear to have the same trouble. Underlying some of the passion in this debate seems to be differing worldviews: Are different peoples fundamentally the same or are the differences among different peoples substantial and

significant? These different worldviews, universalist or particularist, are not unique to language and thought.

There remains an important issue on which there are no data. How large are the effects of language on thinking? How do they compare to the other influences on thought, home, education, religion, culture, gender, genes? How extensive are the effects of language on behavior? Do speakers of *stuff* languages find it easier to recycle than speakers of *kind* languages? Do speakers of languages without a future tense have more problems with future planning? Would a German architect be more likely to design a delicate frilly bridge and a Spanish designer more likely to design a massive, sturdy one? Either way, the forecast is for more insightful research.

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