KEN-KEN SUDOKU 2 DEAN'S GRANT WINNERS

HUDN

Issue 2 Vol. 4
SUMMERPOCALYPSO 2012

The HUMAN DEVELOPMENT NEWSMAGAZINE

Pick a number, 1 or 2.

Say the color of the word in the box with your number.

1

John

2

Black

In this issue

Welcome to the HUDNewsmagazine...

students faculty staff instructors researchers investigators colleagues families friends

leaving NYC via JFK 5/11/12

Photo: Shang Chen

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How can metacomprehension change the way we learn?

Metacomprehension refers to an individual's ability to monitor his or her text comprehension. Based upon cognitive load theory and cognitive anchoring theory, it is hypothesized that collaborating with another will increase an individual's metacomprehension accuracy. This study investigates metacomprehension accuracy among collaborating pairs of seventh graders. It addresses the question of whether being asked to make comprehension and performance judgments about their partners as well as about themselves affects participants' metacomprehension accuracy.

The study is tiltled, *Metacognitive Judgments of Comprehension and Performance during Collaboration.* It uses a randomized posttest-only control-group design. Pairs are randomly assigned to either a **judge-both condition**, where participants make judgments about themselves and about their partners, or a **judge-self-only condition**, in which participants make judgments about themselves only. Participants in both conditions read several passages, discuss the passages with their partner, collaborate with their partner to generate keywords about the passages, make metacognitive judgments about comprehension and performance, and answer reading comprehension test questions.

Gamma correlations are computed between participants' test scores and judgments. Based on the results of a preliminary study previously conducted with college students (N=32), and on the findings reported in the current metacomprehension literature, students in the judge-both condition are expected to demonstrate significantly greater metacomprehension accuracy than students in the judge-self-only condition. In other words, students asked to make comprehension judgments about their partners as well as about themselves are expected to be more accurate than students who make judgments only about themselves.

Award Winning Proposal
by Lisa Pao with
Professor Joanna Williams

The Theory:

HUDN Table of Contents:

The Questions

1) Are middle-school students able to make accurate metacognitive judgments about their text comprehension and about their subsequent test performance?

2) Does being asked to make comprehension and performance judgments about their partners as well as about themselves have an effect on students' metacomprehension accuracy?

The Design

Hypotheses. **Based on the results of a preliminary study conducted with college students (N = 32)**, and on the findings reported in the current literature, researchers expect that students in the judge-both condition will demonstrate significantly greater metacomprehension accuracy than students in the judge-self-only condition. In other words, students asked to make comprehension judgments about their partners as well as about themselves will be more accurate than students who make judgments about themselves only.

Subjects. This study will involve N = 120 seventh graders from New York City public schools. Seventh grade was chosen because the only existing study in the current literature that has investigated metacomprehension in children (de Bruin et al., 2011) found significant results with this age group.

Materials. This study will use comprehension passages and questions adapted from standardized tests of reading comprehension. Six passages will be selected, and each passage will be accompanied by six multiple-choice comprehension questions. The passages and questions will be presented to participants in a test booklet. Order of passage presentation will be randomized across participants.

Procedure. This study will take place over two days. On each day, participants in both conditions will complete a series of activities. Figure 1 lists the activities in the order in which they will be completed. Figure 2 lists the types of metacognitive judgments to be made in each condition.

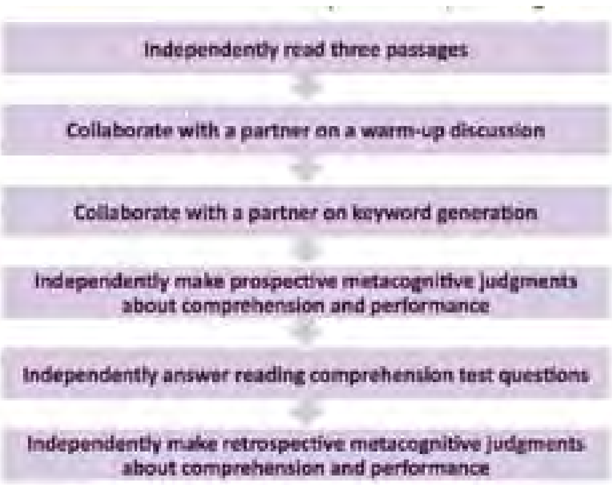


Figure 1. Activities to be completed on each day

Figure 2. Metacognitive judgments in each condition

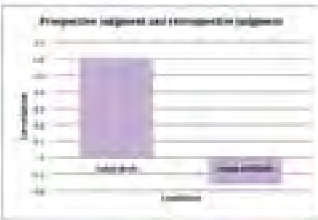
Preliminary Study:

Table 1.
Test performance, comprehension judgments, and performance judgments

Condition	Test performance	Comprehension self-judgment	Prospective self-judgment	Retrospective self-judgment
Judge-both	4.13 (0.97)	4.78 (0.78)	4.47 (0.81)	4.16 (1.26)
Judge-self-only	4.13 (0.95)	4.53 (0.53)	4.31 (0.60)	4.25 (0.68)

Table 2.
Metacognitive judgments about partner

Condition	Comprehension judgment about partner	Prospective judgment about partner	Retrospective judgment about partner
Judge-both	4.78 (0.73)	4.59 (1.13)	4.50 (1.28)



A total of N = 32 college students (22 female, 10 male) from an introductory psychology class in a public college in New York City participated in the study. The average age of participants was 21.10 years (SD = 1.89), with a range of 19-28 years of age. Pairs of participants completed the experiment in a classroom setting during a 50-minute course period, with their regular instructor supervising. Participants formed themselves into pairs based on where they were seated in the classroom. Pairs of participants were randomly assigned to one of two conditions: judge-both or judge-self-only. There were 16 pairs. Each pair read two expository texts, adapted from Scientific American Mind magazine, before making metacognitive judgments and taking a comprehension test.

Preliminary Conclusions:

For both conditions, the gamma correlation between test performance and retrospective performance self-judgment was statistically significant. However, the correlation between test performance and prospective performance self-judgment was not. In other words, participants in both conditions were more accurate when reflecting on their performance after taking the test than when predicting their performance before taking the test.

For the judge-both condition, the gamma correlation between mean prospective and retrospective performance self-judgments was significant. Participants who were asked to make judgments about their own performance and also that of their partner provided prospective and retrospective performance judgments that correlated more strongly with each other than did participants who only made predictions and reflections about themselves. One possible interpretation of this finding may be that performance reflections were more consistent with the performance predictions for participants in the judge-both condition.

Within the judge-both condition, the gamma correlation between mean test performance of partner and mean retrospective performance judgment about partner was statistically significant, indicating that participants who provided retrospective estimates of their partners' performance did so with reasonable (statistically significant) accuracy. Metacomprehension accuracy was slightly greater for judgments made about one's partner than for judgments made about oneself (0.57 compared to 0.48); however, although the difference was in the desired direction, it was only marginally significant ($p = .09$).

Within the judge-both condition, the gamma correlation between mean prospective performance judgment about partner and mean retrospective performance judgment about partner was statistically significant. Additionally, participants were significantly more consistent when making judgments about their partners than about themselves (0.74 compared to 0.61; $p = .05$).


Photo: Shang Chen

Lisa Pao is a doctoral student in the Cognitive Studies in Education program at Teachers College, Columbia University working with Professor Joanna Williams. She holds an AB in English and American Literature and Language from Harvard University, and an MA in Cognitive Studies in Education from Teachers College, Columbia University. Lisa also holds a teaching credential for middle and high school English, and has experience teaching 7th and 11th grade English. Her research interests include reading comprehension, metacognitive processes, and the roles of competition and collaboration in learning.

Background:
Laura Lancaster,
Oil on Canvas- *Untitled*

THE IMAGINARY WORLDS OF JOHN B. BLACK

Manipulating mental models of scenarios, objects or spaces, whether real or imagined, is a gateway to understanding any problem space. It allows us to be adaptive and adjust to changes in time and space and makes us better problem solvers. As the director of the Institute for Learning Technologies (ILT), Dr. Black leads efforts integrating technology into the classroom where students use their movements, gestures and touch along with sight and sound to embody what they are learning. Dr. John B. Black is the Cleveland E Dodge Professor of Communications and Technology and Chair of the Department of Human Development. His academic pedigree includes his work at MIT, The United States Army Command and General Staff College, and Stanford University and teaching at Illinois and then Yale before coming to Teachers College. If you've ever had a conversation with Professor Black about educational pedagogy, then you're familiar with his interest in mental models (and science-fiction…) and how humans imagine and interact in an imaginary world.

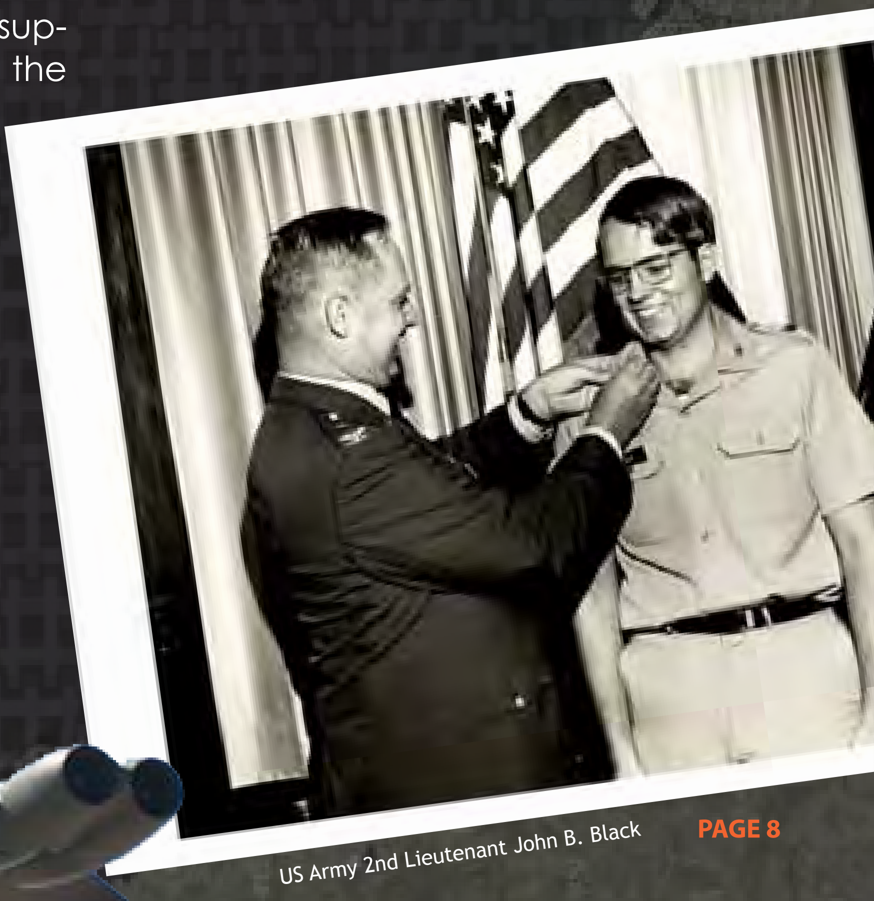
Welcome to (t)his world.

On the eastern rim of the Gulf of Mexico along the west coast of Florida lies the port city of Tampa. Inhabited for thousands of years by many different Native American Tribes, the area was first westernized by the Spanish explorers in the mid 1500's. In the new world, Tampa Bay became known for its electrostatically charged atmospheric activity — a.k.a., lightning as well as a shelter for passing ships and their sailors. This vortex on planet earth became an attractive siren to voyagers of the seas. Until Florida joined the United States in 1813, Tampa was a town pillaged and plundered by packs of pirates. And that's where John Benjamin Black's world began. "It's an interesting town that celebrates their identity with the buccaneers that used to raid their community," Professor Black laughed.

1591 map of Florida by Jacques Le Moyne de Morgues

Growing up at the height of the Cold War, Professor Black remembers the public safety films on projectors that demonstrated duck and cover that supposedly provided protection from the constant threat of thermonuclear war! "MacDill Air Force Base is right there in Tampa. When I was a kid, we'd see the B52's cruising overhead. That aircraft was the main part of the US's nuclear force… When we were young, we expected the world to end in nuclear war; we figured since we lived near the base we were toast. That didn't happen, which is good." Today, MacDill is Central Command for the United States Armed forces and where they run all of the Mid-east conflicts, including Iraq and Afghanistan."

B-52 Flying Fortress



US Army 2nd Lieutenant John B. Black

Sly JBB on Tronmbone.

In Tampa's public schools, John was a self-actualized learner. "I hated school and was disengaged until 9th grade. Students were on educational tracks then that determined what your academic trajectory was for high school. Once it was determined, there wasn't anything you could do about it. All my friends had been tracked for advanced math and I wasn't. That was my low point with school," Professor Black sighed.

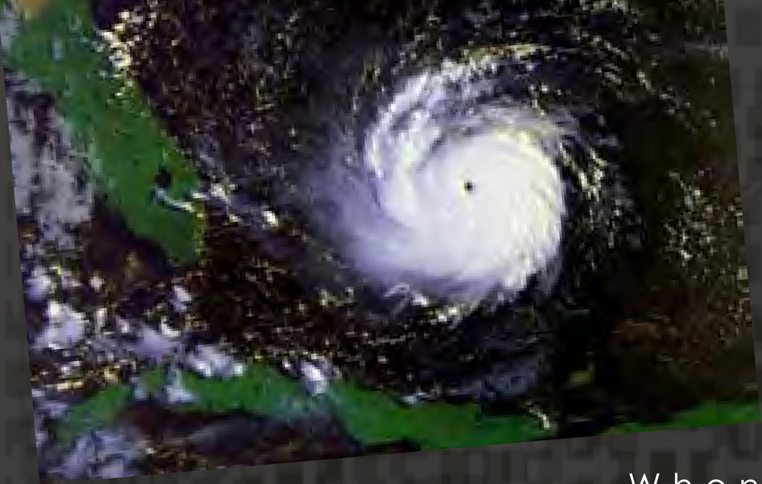
"See, my outlier in school was music. I played trombone in the school band and orchestra all the way through college. I was first chair trombone player in the state and started playing at the new local college USF (University of South Florida) during high school. In exchange, they let me take courses and lessons for free. There was a point when I thought about applying to music conservatories but, I decided to go the science-math route instead." "If it wasn't for my 9th grade math teacher, my path might've been very different. She would let me go to the back of the room and go through the book at my own pace. Even though I was ignoring what was going on in my classes, I was learning math and getting interested in learning for its own sake."

"I didn't have any special arrangement with the teachers or anything but I started doing the math classes on my own. I tried to get into the accelerated track with my friends but they would not let me switch— even though I did very well on all the exams." When John ran out of high school books, he went to USF to get their books. "In my free time," Professor Black recalled as he reclined back on the couch in his office and hammocked his hands behind his head, "I used to read a lot of science fiction. In a lot of those books, many of the scientists who were forging the future of mankind went to institutions like MIT and I would imagine my possible self in that world... studying at one of the most prestigious schools in the country. So, I started thinking about how to get to college."

"Once I knew I wanted to go to college, I applied for an Army ROTC (Army Reserve OFficers Training Corps) Scholarship. It was an essential solution to pay for college; I would give them four years of service as an Army officer later, if they pay my expenses for MIT (which wasn't Cheap)! I worked hard to understand the type of thinking they were looking for with the SAT's, scored well, and with my musicianship and my math, got in to MIT and was awarded the scholarship."

Insert montage of a young man, John Benjamin Black, saying goodbye to his family, to Tampa and traveling north for the winter, not a snow bird, but, a sunbird— if you will?

MIT Main Hall



When Professor Black got to Boston, he felt for the first time that he was where he belonged. "The richness of the area, with its the cultural heritage, the arts, the theatre and music was a welcome change from the swashbuckling of Tampa. When I got to MIT, there's the main hall that stretches into a lengthy corridor with offices, classrooms and the research labs all clustered like hubs. I walked through, marveling at the way it integrated the discovery of knowledge through research and instruction." "I remember not long after going to see a Fellini movie down at a local theatre. It was unlike anything I had experienced – I realized I was in a different world."

At MIT, unlike high school Professor Black was selected for in a new advanced track that the school was trying. "The college was testing a new experimental math track for selected students to skip calculus and go directly to Real and Complex Analysis that dealt with mathematics on a more theoretical level. I learned that there are different levels of understanding to subjects. Intro courses are often not the same material nor are they taught to really teach you the subject properly. Skipping these classes allowed me to finish the math major quickly, and I started taking a lot of other classes too. Even so, it wasn't until the very end of my undergraduate time that I took my first psychology class."

Professor Black's senior honors project was on neural networks using finite-difference differential equations. That was back when he was still figuring a career in mathematical psychology. "Each summer, I would find a different venture to pursue. I would take classes at Harvard or earn money doing things like make liquid nitrogen for MIT labs. The summer before I graduated, I took a group dynamics class on encounter groups and got hooked up with this woman from Smith College and we fell in love.

"The next year, when I graduated and became an Army officer, they sent me to California, but she was not finished with her bachelors degree. So, we got married at Christmas time. Turns out, the school policy allowed wives to go with their husbands to finish their degrees at other institutions." The newlyweds set trail west.

During his first two years in the army, Professor Black was stationed in Sacramento, California,

US Army Command & General Staff College

snoopingly close to Stanford. "The psychology class he took at the end of his stint at MIT had redirected his interests. A couple years into his service, 2nd Lieutenant John B. Black was relocated to Ft. Leavenworth, Kansas as a new staff member at the US Army Command and General Staff College, teaching computer science to military graduate students preparing for higher command.

"They [the Army] wanted all these Majors and Lt. Colonels to learn to program computers and I was working on creating a CAI (Computer Assisted Instruction) course to teach them. This was 1973, so that was about all you could do with computers was program them. Some of the officers had been working with computers already, others had not, so they wanted to develop CAI that would individualize the learning. This is when I got interested in Educational Technology, but I had a feeling we were going about it all wrong so I wanted to find out more about it."

And that's when John imagined a world where...

"The ARPANET (the military precursor to the internet), gave us access to studies that the military had been funding. I read through them and found work by Jaime Carbonell. He had done his dissertation at MIT using Artificial Intelligence (AI) methods to represent information in a knowledge representation that was capable of answering and asking questions. I realized right then something was amiss-we needed accurate representations of knowledge. We were trying to teach declarative knowledge of procedural information."

"At the end of my military service, I made the decision to go to Stanford for my doctorate. I was going to work with Dick Atkinson on Cognition and CAI. Dick had two separate teams, one working on CAI and the other in cognitive psychology. Being in the psych department, they require a first-year research project. I had recently read an article by John Bransford about knowledge schemas and found it fascinating. Researchers were composing semantic networks but that seem to capture higher-level knowledge. Things like schemas, allowed seeing the forest in addition to the trees. But Bransford had developed a way to explore schemas through memory errors when remembering stories. When I asked Dick Atkinson if we could do experiments about the memory errors people make when remembering stories, he said he didn't see how story recalls were useful data. Plus, he was leaving Stanford. He had been selected as the Director of the National Science Foundation (and he later became President of the U. of California). I had to get a new advisor."

"A week later that I ran into Gordon Bower who told me he had heard that I was interested in memory for stories and that he was interested in that too. Our collaboration took off. We investigated how people understood texts and the inferences they formulated from them (as indicated by memory errors and reading times). It wasn't exactly ed-tech, but we completed some good work on higher-level structures like schemas and scripts. It led later to my dissertation work. The dissertation focused on story worlds (later known as imaginary worlds) and investigated how people connect the ideas and information they read to the imaginary worlds that they construct in their minds."

"I did four studies where people were reading different stories that I had written, about characters who pursued some goal after some situation happened. My hypothesis was that readers would remember characters' actions better when those actions moved the character towards their goal rather than had no effect. It's interesting, that here I was, in graduate school, writing different versions of science fiction stories that brought me back to my childhood affection for that literary genre. Plus, by using science fiction, we could create different stories with varying details and create different conditions for testing the creation of imaginary worlds. In our results, we found that memories were better for goal directed actions and eventually published the study as Story Understanding as Problem Solving [Black & Bower, 1980]."

Stanford University

"Meantime, another exciting part about being at Stanford in the 70's was the growth of Silicon Valley. The use of computers in daily human activities spurred the field of Human Computer Interaction (HCI) researchers. The now famous "mother of all demos" had already been given by Douglas Englebart at a conference in 1968 presenting new technologies developed at Stanford's Augmented Research Center and by the time I was at Stanford, Xerox had opened its new research center not far from campus called the Palo Alto Research Center (PARC). I found myself working there a lot of the time as well. At the Xerox PARC, each desk had its own networked personal computer (the Alto)

Xerox Palo-Alto Research Center

with its own screen, graphic icons, a keyboard and a mouse- it was like stepping out to 1990 but in 1975! Back at Stanford, the computer environment was still wrought with mainframes that took up entire rooms and terminals that looked like typewriters. Incidentally, it was a few years later when Steve Jobs toured Xerox PARC that he wound up hiring most of the Alto team who eventually produced the Apple Computer that introduced all these innovations to the rest of the world. Xerox never appreciated what had been created there, but working there was certainly an amazing opportunity that got me interested in HCI."

Before Professor Black had even finished his doctorate at Stanford, he and his wife (who had since earned her PhD at Berkeley), had both been hired for positions at the University of Illinois, Chicago. Professor Black continued his research in Human Computer Interaction as a consultant for Xerox PARC for a few years after finishing his degree. At the same time, the Sloan Foundation had set up a huge fund for the emerging interdisciplinary field of Cognitive Science at Yale (and a few other places) and two professors and researchers, Schank and Abelson, were holding a summer session to introduce their new cognitive science approach—centered around Schank's work with scripts in computer science. They were particularly interested in Professor Black's work on scripts and schemas with Gordon Bower and invited John to attend. "By the end of the summer session, Schank was asking what it would take to get me to Yale. I described a position, returned to Stanford, defended my dissertation, headed to Illinois, taught for one year and left for a professorial position at Yale the following fall."

Dr. Black was a professor at Yale for six years. His work at Yale with Elliott Soloway, the other junior faculty member hired in Cognitive Science at Yale, renewed his interest in educational technology and combined it with interests in mental models that we create in our imaginations. "Years ago, before everyone had a personal computer, campuses had mainframes. Doctoral students interfaced through terminals and had to learn this new word processing software for writing their dissertations. The software had been written locally in New Haven by two computer science graduates and was very jargon intensive [think DOS-esque commands], which presented us with an interesting opportunity. Since most incoming students had never seen these programs before they began their work, we had a chance to experiment with the learning process as the doctoral students gradually became experts at using the word processing software"

Yale University

"We took a lists of words (i.e., the commands for operating the software), paired them, and had users rate how similar the two commands words on a likert scale. A hierarchical cluster analysis revealed different trees of groupings depending on rating the similarity of the commands. Novice users chose commands that were alternative ways of doing something (e.g, delete and backspace; i.e., by similar function) while expert users'' judgments were by associated pairings (e.g., pick and put, i.e., commands that went together to accomplish a task). Exploratory interviews with the system designers showed that they conceptualized the system in a very different way. The users were conceptualizing the similarity between commands by the rules that governed the program's behavior while the designers were conceptualizing the underlying operations via a mental model of how the system worked. Their deeper conceptualization of how the system worked seemed to utilize an imaginary spatial model of how the system functions. "This study started me thinking about the differences between rule-based and mental-model-based thinking."

"The work we were doing at Yale was great. While I was there, I had a dual appointment in both psychology and computer science. It was great for a few years, but then the cognitive science program started to unravel, and the grant money would run out in a few years. Up until that point, my wife and I still hadn't planted any roots. She was at Berkeley while I was at Stanford. We were only at Illinois for a year. She was at Columbia while I was at Yale. Although we had grown accustomed to the commuting lifestyle, it wasn't conducive to our desire to have a family. That's when I started looking for work that would accommodate her work."

Fortunately, TC had a job opening at the same time, made John a good offer, and he took it (turning down offers from NYU and IBM Research). John first met Dr. Ernie Rothkopf (see HUDN, Spring 2011), a professor at TC, back in the 1970's during the summer after Professor Black's second year at Stanford. He came to work for Dr. Rothkopf at Bell Laboratories in New Jersey as a visiting researcher investigating people's

understanding of text. "When the government broke up the Bell monopoly, all the researchers there dispersed to the leading universities and Dr. Rothkopf ended up at Teachers College. In all the interactions that I had with Ernie up to that point, we loved to argue, and yet, Ernie was instrumental in bringing me to Teachers College. It worked out well while we co-taught Cognition and Learning – arguing the whole time."

"Another big influence in my research came from my children," Professor Black notes. "My oldest daughter had problems learning early in her school career. She was good at imagery and at kinesthetic learning but didn't seem to learn well from many of the traditional approaches to education. Consequently, her mother and I helped develop ways for our oldest daughter to learn and overcome her verbal limitations. She was and is a very good dancer and actor and we saw this as an entry point to develop effective strategies for her to learn. We helped her learn to diagram and map out concepts, associating them to the movements she was doing. The private school in the city that cost a fortune had rejected her as being too learning disabled whereas the Public school out in Westchester had her in the mainstream curriculum within one year. Looking at my daughter's use of visualization and movement to help her with learning the verbal material she struggled with started me thinking about embodied and grounded cognition."

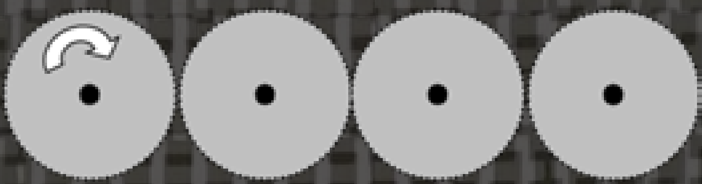
"For years, I had been pondering mental models and how they differed from other knowledge representations. I started reading work by Glenberg on embodied cognition and Barsalou's work on grounded cognition, and began to realize that creating a perceptual simulation really changed the nature of the mental models that students create. Thus far, this approach has worked out quite nicely and become a great source for our current lab work at ILT. It is serendipitous that I had done a series of studies while a student at Stanford that are now considered an early examples of this approach. Those studies showed that a switches spatial points-of-view can affect reading times and memory accuracy—I just didn't fully realize its implications at the time. For years, those studies were ignored at the time but have become highly referenced today." Here At TC, what really moved his work on mental models forward was his decision to get it in gear, so to speak...

Professor Black's work with former TC student Dan Schwartz (PhD, 1992; currently professor,

founder and director at the AAAlab at Stanford, see HUDN, vol. 1, issue 2) asked participants to use their imagination to solve similar questions speculating on the direction that the gears would turn. With no pictures, participants were given gear combinations and told to imagine the gears and correctly anticipate the direction a gear would turn. "The participants worked in pairs and were instructed to solve the gear problems together while we videotaped them. Surprising to us at the time, the participants used gestures that depicted the gears moving and interacting to help solve the problems!"

"Most participants thought that all the gears move in the same direction initially, but as they started reasoning the correct directions of rotation, they began using hand gestures. Additionally, the communicative aspect of the dyads lent itself to more explanatory language and over time they began abstracting their gesturally depicted physical models into mental models. The more they practiced; the less they explained out-loud; the less they gestured and the more they moved towards developing a rule based method for determining the correct direction that a given gear would rotate. Their learning process culminated in concise language centered around a symbolic rule that allowed them to calculate it very fast (e.g., are there an odd or even number of gears; i.e., a parity rule).

If you put four gears in a row and the leftmost turns clockwise,



what direction will the last gear turn?

"However, when we gave participants a ringer like a circular chain of gears, we saw that a significant number of participants shuttled back to the mental models to figure the solution: The idea being, that you can develop a parity rule and still have access to you mental model as a tool."

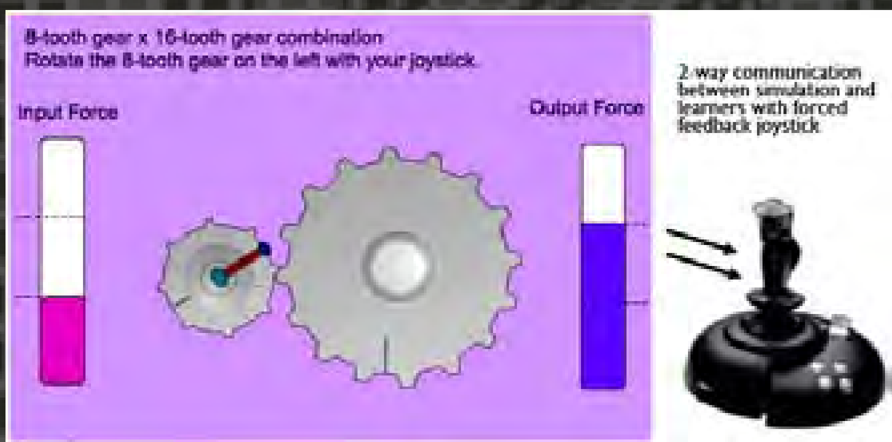
From this, Professor Black and Dr. Schwartz gained insight about how our thinking develops and how cognitively flexible reasoning and real understanding can involve shuttling between rules and mental models They also learned that gestures can play a role in embodying the learning process and grounding cognition (see Schwartz & Black, 1996), and that perceptual fading can help transition between models and rules. Professor Bob Goldstone of Indiana University has done further investigations of this fading process in mental models, which he published and presented at a Department of Human Development Colloquium (HUDN, Vol. 1 Issue 1)

"Of course, now the next buzz in the learning sciences is 'can we not only produce robust understandings of given problem spaces and also be adaptive in our approaches when the problem space is dynamic (see HUDN Summer 2009)." When cognitive psychology began employing the computer metaphor in the 50s and 60s, the downside with computers remained the rigidity of their structures. But now, technologies that can adapt and facilitate adaptable thinking are the new focus. In fact, Professor Black's work in 1979 demonstrated that scripts often overlap and that they are not rigid structures. Dr. Roger Shank, one of the professors who brought Professor Black to Yale, eventually wrote a book called, Dynamic Memory, about the flexibility of strategies and how this parallels the activity in our mental activity as well as physically in the brain. Some of the newest research is reformulating the construct of working memory not as a localized area of the brain that processes information, but rather as a distributed function of the brain."

The work that takes place here in the Department of Human Development is some of the most important here at Teachers College. Over the last few years, Professor Black, who is also the head of the department, has emphasized that, "We, as an institution, have to address all the levels of development: situational, cognitive, and biological. The challenge is to do work that integrates on all three levels. The description of the mental model is the cognitive, but what needs to be happening in the world that integrates perception and then lastly, what is the neurophysiological basis of that. The key is that these are not mutually exclusive but are interdependent methods."

"In our department [HUD], we are trying to figure out the attributes of educational environments that allow effective learning and transfer to other domains. Since our lab focuses our investigations on how the embodied and grounded approach can make learning more accessible to all types of learners, we are starting to get great traction. This years dissertations dealt with people learning computer programming, history and math by acting problems out, using tools, employing avatars, and programming surrogate robots to perform activities (see Subway Summit, this issue HUDN, for the research of Dr. Saadia Khan, Dr. Cameron Fadjo and Carol Lu) .

Recent doctoral graduate Insook Han (Ph.D., 2011) furthered Professor Black and Dr. Schwartz work on directions of gears to understanding gear ratios. Dr. Han developed software that utilized a force feedback joystick built by Microsoft that provided resistance so that students could feel the changes in torque resulting from the differences in gear ratios- embodying their learning process (see Han and Black, 2011).



More recently, Dr. Chaille Maddox (TC PhD, 2012), in collaboration with Professor Karen Froud's EEG lab and Professor Black, used neuroimaging to monitor how participants process perceptual simulations of chains of rotating gears. Participants' expectations about the direction that additional gears would rotate produce electrophysiological activity in different areas of the brain at different times depending on whether the participant is using a mental model or a parity rule. Analysis of 100 ms epochs revealed broad frontal parietal network activation in the brain (in support of other fMRI studies) as well as evidence that the brain processes parity rules much like a syntax whereas mental models are processes more like semantics. This provides further evidence that the brain shuttles between mental models and symbolic representations."

Currently, ILT is running a number of projects looking at an embodied approach to solving word-problems, physics problems, math problems and more. The researchers are finding ways to employ the usage gesture and touch to learning, including developing games and perceptual simulations. If you are interested in the work that Professor Black and his students are doing, you can email him at: black@tc.columbia.edu.

Ken-Ken!

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4	5	3				1	8	9
		8						7
	3	1	7					5
2	7		9	3				
	9							

TEACHERS COLLEGE COLUMBIA UNIVERSITY

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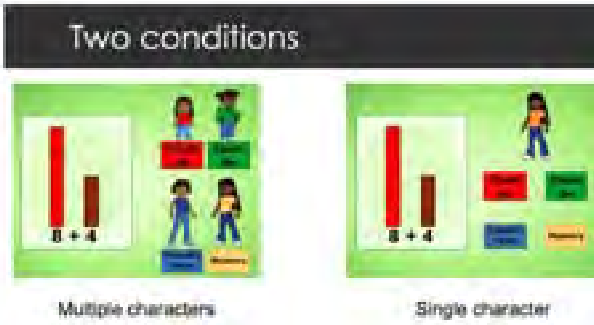
Each year, the graduate schools in the surrounding NYC-metro area get together to share their research in cognitive science and education. Teacher's College HUD doctoral students shared their research with other students and faculty from Fordham, NYU, Rutgers, and CUNY, and now share their work with us.



The study explores how children's understanding of **narrative structure** interacts with varying **numbers of pedagogical agents** that teach complex information. Specifically, the study investigate how multiple strategy characters (versus a single character) affect first graders' ability to utilize different **addition strategies** as well as progress towards more **efficient strategies**. Lower performing students in the multiple character condition were less accurate, yet were more likely to use an advanced strategy. Given the use of an advanced strategy, they were more likely to give a nearly accurate response (+ or – 1), indicating that these students were taking more risks in trying out new strategies. These results suggest that improved performance on addition tasks should not be judged based on accuracy alone. A careful analysis of strategy use in conjunction with exact accurate and near accurate answers gives a more complete picture of children's strategy development.

contact
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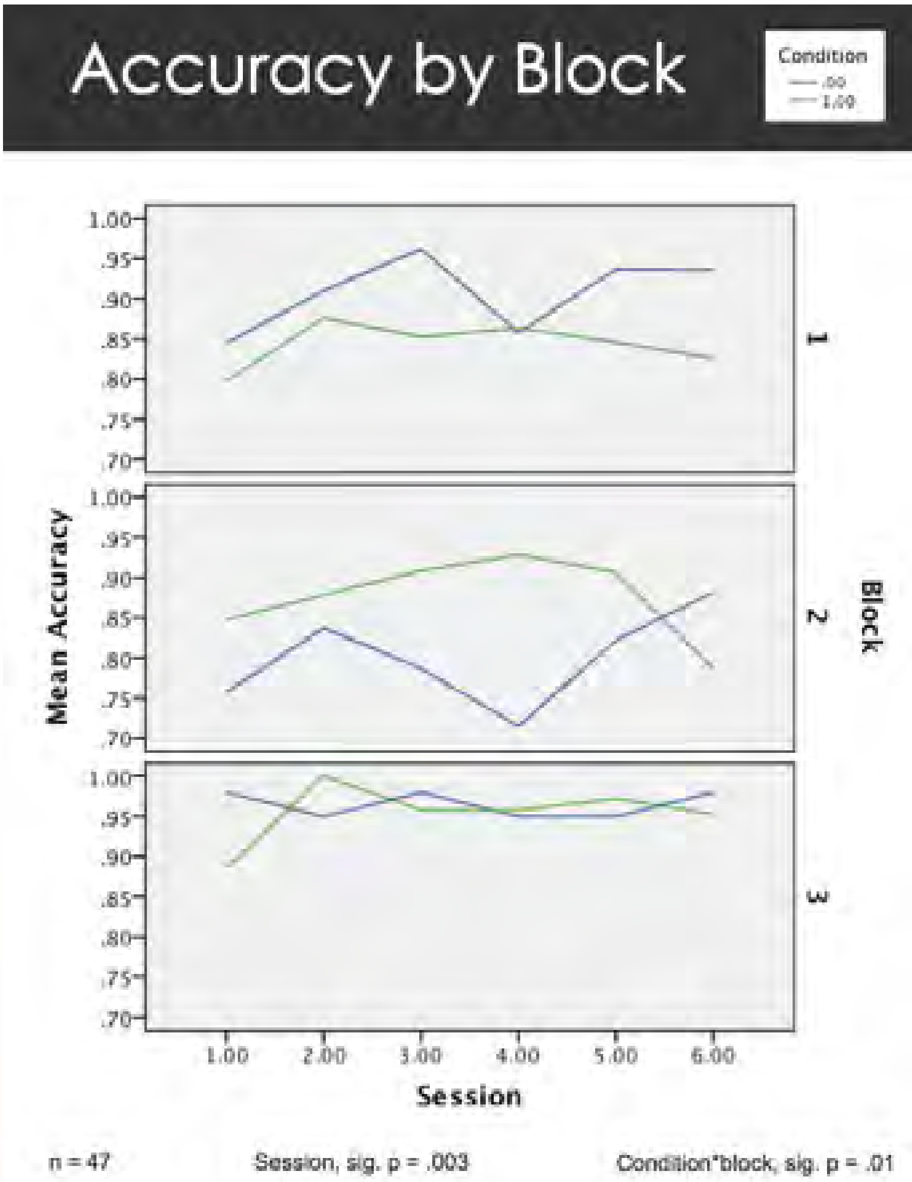
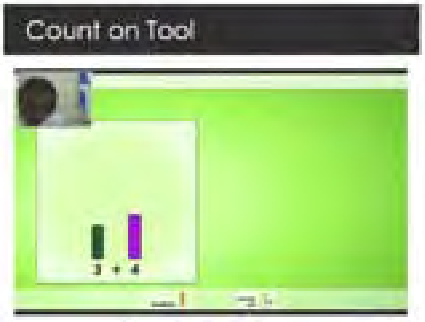
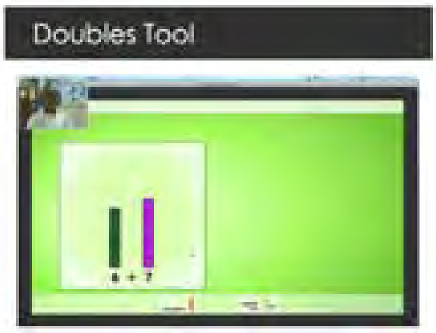


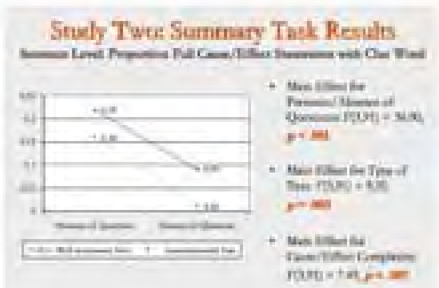


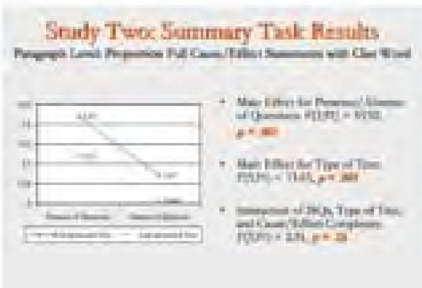


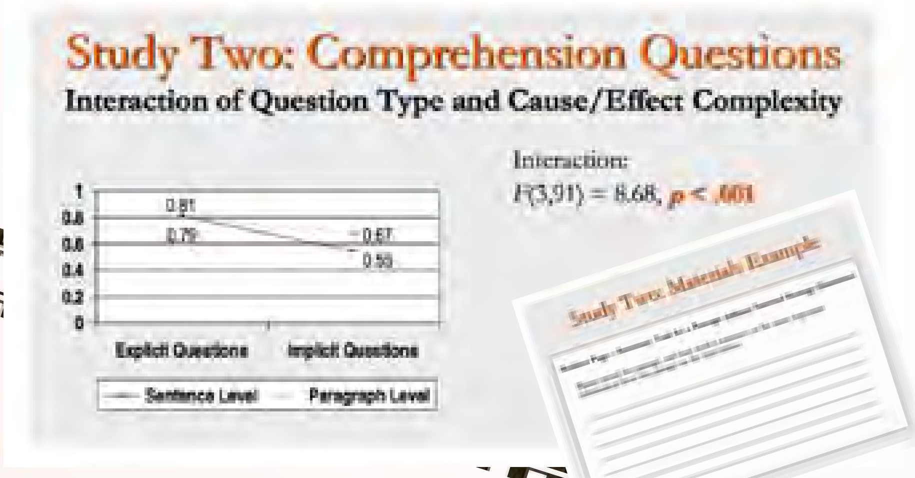
The Effectiveness of Inserted Strategy Questions on Elementary Students' Comprehension of Well-Structured and Less-Structured Expository Text

The effects of **inserted strategy questions** (ISQs) and structured text on fifth grade students' comprehension of **expository text** passages that presented the cause/effect text structure at the sentence level (least complex) and at the paragraph level (more complex) were examined. Two studies were conducted to investigate this relationship. In the first study, an independent factorial design was utilized with two *between-subjects variables* (**ISQs** and **structured text**). Based on the positive findings from the first study, a second study was conducted that added a *within-subjects variable* (**cause/effect complexity**). A total of 48 fifth-grade students in the first study and 95 fifth-grade students in the second study were asked to read expository text passages that presented the cause/effect structure at both the sentence level and the paragraph level. Students were randomly assigned to one of four conditions: (1) ISQs present with well-structured text; (2) ISQs absent with well-structured text; (3) ISQs present with less-structured text; or (4) ISQs absent with less-structured text.

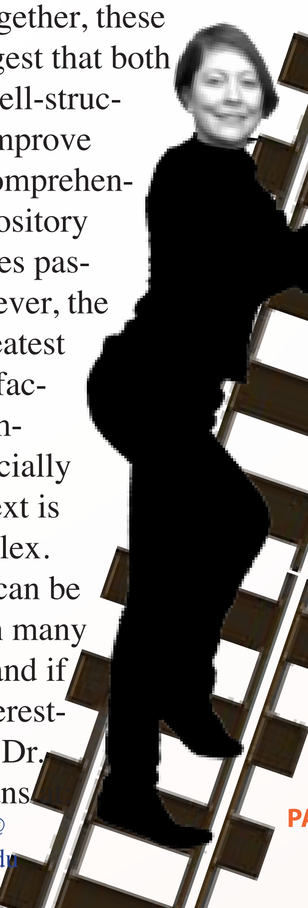
In both studies, the effectiveness of ISQs and well-structured text was measured by performance on a written summary task. For the second study, a comprehension questions task was added. Analyses of variance (ANOVA) were carried out. In the first study, main effects of ISQs and structured text were found on the written summary, as was an interaction between these two factors when the cause/effect structure was presented at the more complex level. In the second study, main effects of ISQs, structured text, and cause/effect complexity were found on the written summary task, but not for the comprehension question task. While the interaction between these three factors did not reach conventional significance on the written summary task, the relationship was investigated further due to our findings from the first study.





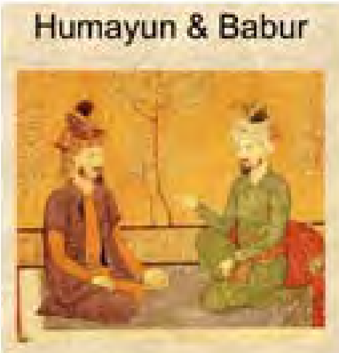


Taken together, these results suggest that both ISQs and well-structured text improve students' comprehension of expository social studies passages; however, the effect is greatest when both factors are combined, especially when the text is more complex. This work can be extended in many directions and if you are interested, contact Dr. Jill Ordynans jill.ordynans@tc.columbia.edu



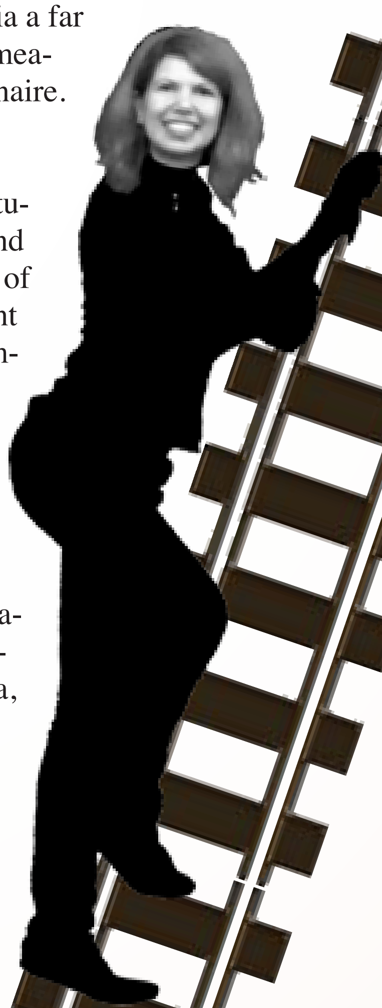
SURROGATE EMBODIED LEARNING in SECOND LIFE

Saadia Khan presented the results of a pilot study that informed her doctoral dissertation. Based on previous research and **embodied cognition theories** (Barsalou, 2008a, 2008b; Glenberg, 2008), the study investigated the effects of **embodied emotional affect** and **embodied learning environments** on adult learners' **memory retrieval** of novel (unfamiliar) historical text, near transfer, far transfer and the motivation to learn history. The study examined three types of embodiment: (1) **surrogate** embodiment, (2) **imagined** embodiment, and (3) **affective** embodiment. Imagined embodiment refers to consciously engaging one's imagination to mentally picture movement or action (Glenberg et al., 2004). Surrogate embodiment refers to physically manipulating an agent (e.g., an avatar), which has been designed to represent a particular object or person (Black et al., 2012). Embodiment of emotional affect refers to physically performing an action associated with the physical manifestation of affect (Glenberg, 2008; Havas et al., 2007).

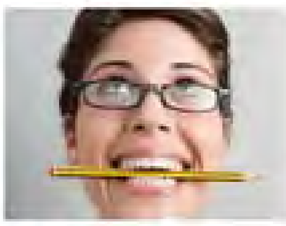


The study was designed as a 2x3 factorial posttest-only control group design with two factors: (1) Embodied Affect (EA) with two levels: positive Embodied Affect (EA) and No Affect (NA), and (2) Type of Learning Environment (TLE) with three levels: Surrogate Embodiment (SE), Imagined Embodiment (IE), and No Embodiment (NE). The dependent variables were memory retrieval measured via a memory retrieval test, near transfer of learning (to history) measured via a near transfer test, far transfer of learning (to literature) measured via a far transfer test, and motivation measured via items on a questionnaire.

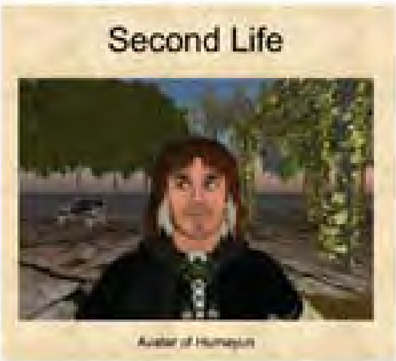
Avatars chatting



Sixty-six graduate student volunteers (64% female; 36% male) graduate students volunteered to participate and were randomly assigned to six groups. Participants were assigned to one of three types of learning environments: Surrogate Embodiment (SE) in the multiuser virtual environment (MUVE) Second Life, Imagined Embodiment (IE), and No Embodiment (NE) (control). Half the participants in each learning condition received a positive embodied affect manipulation (pencil in teeth inducing a smile, *see* Strack et al., 1988) before the learning environment manipulation while the other half (control) did not.



Type of Learning Environment (TLE) manipulation, all participants were given the same historical text about Humayun, the Mughal emperor of India, printed on paper along with pictures/illustrations of the main characters. After reading silently, participants received different instructions depending on their group. Participants in the Surrogate Embodiment (SE) groups role-played in the Teachers College Second Life island, TC Educator, as Humayun's avatar that interacted with the avatar of Shah Tahmasp, another character from the historical text based on a role-play script. Participants used gestures, chat and movements in the role-play sessions.

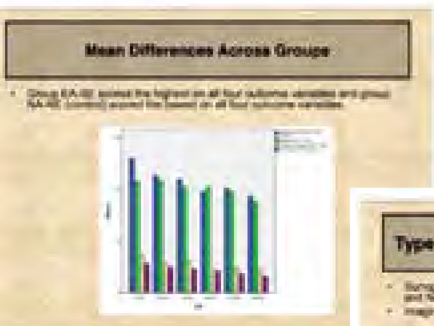


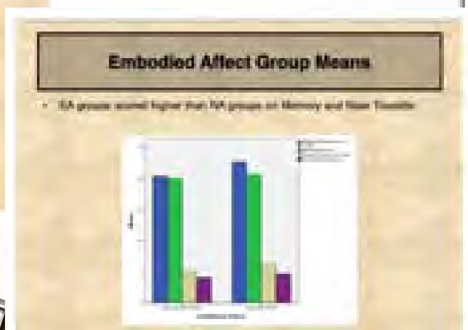
Avatar of Humayun

The Imagined Embodiment (IE) groups were instructed to imagine the actions in the text while reading and imagine the interaction. The No Embodiment (NE) groups were instructed to simply re-read the text to control for time.

MANOVA followed by post hoc significance tests (Tukey's HSD) revealed significant main effects for Embodied Affect (EA) and Type of Learning Environment (TLE) and no significant interactions were found. Embodied Affect (EA) was found to have a significant main effect on memory and near transfer, while Type of Learning Environment (TLE) was found to have a significant main effect on memory, near transfer, far transfer and motivation. Tukey's Post-Hoc HSD tests revealed honestly significant differences between group vectors on all four dependent variables.

Findings indicate: (1) Surrogate Embodiment (SE) enhanced memory, near transfer, far transfer and motivation more than No Embodiment (NE); (2) Surrogate Embodiment (SE) enhanced memory and near transfer more than Imagined Embodiment (IE); and (3) Imagined Embodiment (IE) enhanced memory more than No Embodiment (NE). The results suggest that role-playing via avatars in MUVEs can enhance memory, transfer and motivation more than simply reading and role-playing via avatars in MUVEs can also enhance memory and near transfer more than imagining actions. Furthermore, the results suggest that the more embodiment learners experienced (i.e., when embodied affect was combined with embodied learning), the better they performed at memory and transfer tasks, and imaginary worlds construction (Black, 2007) also played a role in improving performance. It was found that positive embodied affect induced with surrogate embodiment (EA-SE) in Second Life further enhanced memory and near transfer as compared to Imagined Embodiment (IE) and No Embodiment (NE) and embodied affect with imagined embodiment (EA-IE) further enhanced memory as compared to No Embodiment (NE).





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SURROGATE EMBODIED LEARNING in SECOND LIFE

Elementary school students often find science a complex subject to learn (Johnstone, 1991; Millar, 1991). Robotics have been used in previous studies to promote science learning as they provide students an environment to observe abstract concepts through the use of tangible, hands-on objects (Nagchaudhuri et al., 2002; Barker & Ansorge, 2007; Druin & Hendler, 2000). However, few studies have investigated the effects of integrating embodiment and LEGO Robotics to encourage students to physically experience abstract science concepts using their own bodies to enhance their conceptual understanding. This study aimed to examine the importance and role of **embodiment in elementary science learning** through the use of LEGO Robotics. We investigated the following: (**1**) Do teaching and learning with embodied cognition improve children's understanding through LEGO Robotics? (**2**) Can embodied cognition increase students' motivation in learning?

Participants consisted of 48 fifth grades ((28 girls and 20 boys) from three urban public elementary schools in New York City. The data for seven students were not included in our analysis (6 students did not complete the program due to lack of attendance and 1 student was not included because she did not speak English). The students were randomly assigned to one of the three conditions:

- **Control group**: students received traditional lessons on physical science concepts while they engaged in activities with robotics that were not related to these science concepts (n=12)
- **WO- Experimental group** without embodiment: students were asked to participate in activities using robots designed to help them learn physical science concepts (n=15)
- **WE- Experimental group with embodiment**: students engaged in activities related to physical science concepts using robots as well as the embodiment of these science concepts (n=14)

The intervention took place over four 2 1/2-hour sessions for one school and five 2-hour sessions for the other two schools. The difference in the number of sessions was due to scheduling conflicts, however, the total intervention time was equal among the three schools. The first session students were pretested on their knowledge of the physical science concepts and introduced LEGO Mindstorms NXT to our participants. Students were asked to build two different types of robots: a baseball batter robot and a mini golf robot. They

also had the opportunity to create simple NXT programs so that they would become more familiar with programming in NXT LEGO Mindstorms.

Students in the control group received short lessons on the three physical science concepts through traditional lectures. They were then asked to build and play with the robots without engaging in any science-related activities. Students in the two experimental groups were not given these lessons.

They were asked to participate in a series of hands-on activities designed to investigate, learn, and apply the three physical concepts.

Students in the experimental groups were asked to build and program the robots to hit the ball. The robots would then bat a light ball at a designated power level until it hit a ball. The ball would roll for a certain distance. Students were asked to measure the distance of the ball and record it on their worksheet. In the second round, students increased the power level in their program and performed the same activity. They were asked to observe what would happen to the distance when the power level was increased. In part two of the activity, another ball of a different mass was used and students again measured the distance and compared that with the first type of ball they used. Students were required to answer related questions on their worksheet. They observed the relationship between force and mass. Eventually, they found that the greater the force placed on an object, the greater the change in motion. Furthermore, the more massive an object is, the less effect a given force will have upon the motion of the object ("Force and Motion," 2009). In part two of the activity, students tested the identical program of pushing two types of balls with different power levels but this time on another type of surface: a rug. They observed the effect of friction on the motion of the balls and what kind of difference it would have on the distance.

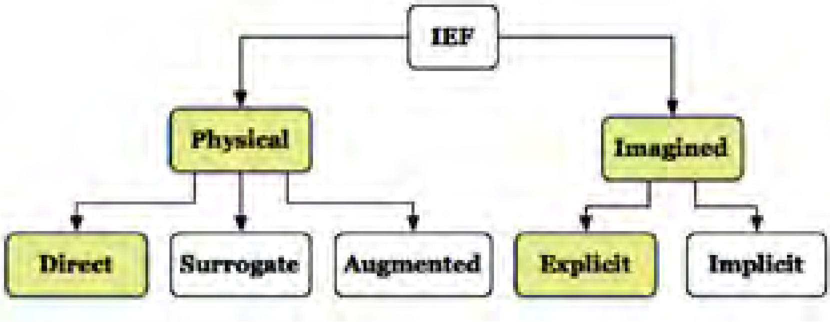
Students in the experimental group with embodiment were asked to imagine themselves as the robots and moved their own bodies according to the instructions given for the challenges. They then programmed the robots to perform related movements. While they were programming the robots, they were also encouraged to imagine the robots' movements. Therefore, in the activity, students in the experimental group with embodiment held the ball in their hands, batted the ball with a certain force, and then observed what happened. In the second round, they held the other type of ball in their hands and physically felt the difference between the two types of balls used. They would see and feel the difference between the mass of the two objects used. In part two of the activity, students batted the two types of spheres on the rug, just like what their robots would do. They then observed the effect of friction on the motion of the objects. After treatment, students in each group were given a posttest with questions that we had created based on the science concepts introduced in the activities.

The results from this study provided evidence that students with the embodied experience had higher gain scores than the students in the control and experimental groups with no embodiment. In addition, students with the embodied experience have higher interest and confidence in learning science with LEGO robotics than students without the embodied experience. This suggests that embodiment can be used to enhance the learning experience with LEGO robotics for elementary school students as well as increase their interest and confidence in science learning. The results from the experiment can help educators in designing science curriculum and instructional materials for elementary school students. If you are interested, you can contact Dr. Lu at:

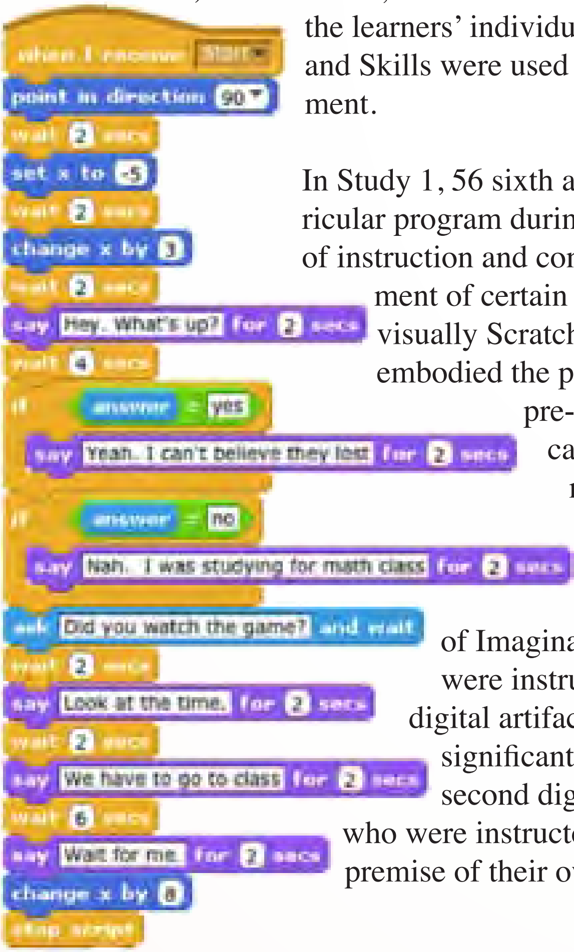
cml2133@tc. columbia.edu

Developing Computational Thinking Through Grounded Embodied Cognition

Two studies were conducted to examine the use of **grounded embodied pedagogy**, construction of **Imaginary Worlds** (Study 1), and context of instructional materials (Study 2) for developing learners' **Computational Thinking** (CT) Skills and concept knowledge during the construction of digital artifacts using **Scratch ™**, a block-based programming language. Utilizing a conceptual framework for grounded embodied pedagogy called **Instructional Embodiment**, learners physically enacted (**Direct Embodiment**) and mentally simulated (**Imagined Embodiment**) the actions and events as presented within pre-defined Scripts. Instructional Embodiment utilizes action, perception, and environment to create a dynamic, interactive teaching & learning scenario that builds upon previous research in embodied teaching and learning.



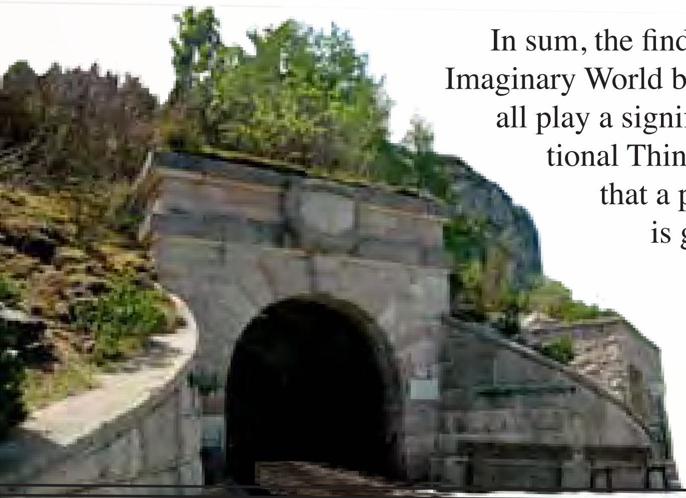
The two studies examined the effects of Instructional Embodiment, Imaginary World Construction, and Context on the development of specific Computational Thinking Concepts and Skills. In particular, certain CT Concepts, such as *Conditionals, Variables, Thread Synchronization, Collision Detection, & Events*, and *CT Skills*, such as abstraction and pattern recognition, were identified and measured within the learners' individual digital artifacts. Presence and/or frequency of these Concepts and Skills were used to determine the extent of Computational Thinking development.



In Study 1, 56 sixth and seventh-grade students participated in a 15-session curricular program during the academic school day. This study examined the type of instruction and continuity of Imaginary World Construction on the development of certain CT Skills and Concepts used in constructing a novel visually Scratch. Main effects were found for learners who physically embodied the pre-defined instructional materials: embodying the pre-defined Scripts led to the learners using significantly more "speech" blocks in their projects and more Absolute Positioning Blocks for "motion" than those who did not physically embody the same Scripts. Significant main effects were also found for continuity of Imaginary World Construction: learners who were instructed to continue the premise of the first digital artifact (Instructional Artifact) implemented significantly more computational structures in their second digital artifact (Unique Artifact) than those who were instructed to create a Unique Artifact with a premise of their own design.

In Study 2, 28 sixth and seventh-grade students participated in 17 session curricular program during the academic school day. This study examined the type of instruction and context of instructional materials on the development of CT Skills and Concepts during the construction

of a video game using Scratch. Similar to Study 1, findings suggest that physically embodying the actions presented within the pre-defined instructional materials leads to greater implementation of many of these same structures during individual artifact construction. The study also showed that as the pre-defined Scripts become more complex (e.g. single-threaded to multi-threaded), the effect of physical embodiment on the development of CT Skills and complex CT Concept structures becomes less pronounced. Findings from this study also suggest that Context has a significant effect on identifying & implementing the CT Skill pattern recognition: learning CT Concepts from an Unfamiliar Context had a significant positive effect on the implementation of both Broadcast/Receive couplings and Conditional Logic and Operator patterns.



In sum, the findings suggest that the type of instruction, the continuity of the Imaginary World being constructed, and the context of the instructional materials all play a significant role in the learners' ability to develop certain Computational Thinking Skills and Concept knowledge. The findings also suggest that a physically embodied approach to teaching abstract concepts that is grounded in an unfamiliar context is the most effective way to integrate a grounded embodied approach to pedagogy within a formal instructional setting.

If you are interested, contact Dr. Cameron Fadjo at: **cameron.fadjo@gmail.com**


A close-up of this bookshelf reveals . . .
. . . a different kind of pulp fiction

Thinking about time is deeply interlinked with actions in space, and gestures are abstracted actions. Four experiments showed that gestures alter thinking about time. Participants heard the same speech accompanied by different gestures. The viewed gestures biased listeners toward circular or linear thinking, toward parallel or sequential thinking, toward moving-ego or moving-time perspectives. Gestures can abstract and show mental models more directly and succinctly than speech.

Learn how
Azadeh Jamalian and **Barbara Tversky**
are finding ways to

Adgestu're Thinking

vs.

The COGNITIVE SICENCE SOCIETY
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Gestures Alter Thinking About Time?!.

As they say, life is just one thing after nother. But there is more complexity to thinking about events in time. Historical and autobiographical events are often regarded as on a timeline, but events can also happen simultaneously, not a simple single sequence. Repeating events like seasons, days, and the cell cycle can be regarded as circular. Moreover, reasoning about events in time entails taking a perspective on the timeline. Two common perspectives are moving-ego, thinking of yourself as moving along a timeline (we're approaching summer), or moving-time, thinking of yourself as stationary on a timeline with events moving past you (summer is approaching) (e. g., Clark, 1973). These perspectives are analogous to a route or intrinsic or egocentric perspective in space; the viewpoint is embedded in space or in time, with ego as the reference (e.g., Levinson, 1996; Tversky, 1996). But just as it is possible to take an external or survey or absolute perspective on space, it is possible to take an external or absolute or calendar view on time, an outside perspective regarding events as ordered by dates. In the case of survey/absolute spatial perspective, the reference points are landmarks and the terms of reference are typically north-south-east-west. For external/absolute/calendar temporal perspective, the reference points are dates or events, and the terms of reference are earlier/later.

Whatever the perspective, how people think about events in time is highly interlinked to actions in space (Talmy, 2000; Tversky, 2011). The strong association between action, space, and time is reflected in the language people use when talking about time, the diagrams they draw when conveying events in time, and the gestures that accompany narratives of events in time. People say time "marches on", we "move through" time, one event occurs "before" another, "time has passed", and "the future is ahead of us" (e. g., Clark, 1973; Evans, 2003; Lakoff and Johnson, 1999, Moore, 2006; Nunez, 1999). People's diagrams of events in time, such as the meals of a day, are typically ordered in reading order on a horizontal line (Tversky, Kugelmass, & Winter, 1991). When relating events in time, English speakers often move their hands from left to right, event by event (e.g. Cienki, 1998); they point frontwards for the future and backwards for the past (e.g. Cooperrider & Nunez, 2009). Language, diagrams, and gestures are ways of externalizing thought, and are congruent with thinking (Tversky, 2011).

If people use actions in space to express their conceptions of events in time, will seeing different forms of actions in space change their understanding of time? We address this question here, by explaining temporal events with identical language but different gestures.

Speakers everywhere gesture while they speak. Most gestures are redundant with the speech they accompany (McNeill, 1992), but gestures sometimes express information that is not expressed in speech (e. g., McNeil, 1992; Church & Goldin-Meadow, 1986; Goldin-Meadow, Alibali, & Church, 1993; Perry, Church, & Goldin-Meadow, 1988). Although some have questioned the communicative significance of gestures (Krauss, 1998; Rauscher, Krauss, Chen, 1996; Rimè & Shiaratura, 1991), there is good evidence that speakers often intend their gestures to be communicative (e. g., Cohen, 1977; Cohen & Harrison, 1973; Alibali, Heat, & Myers, 2001; Emmorey & Casey, 2001), and that gestures, whether redundant or mismatching, influence addressees' comprehension (Goldin-Meadow & Sandhofer, 1999; Thompson & Massaro, 1994).

Can the unique information in gesture alter listeners' mental models of a highly abstract yet familiar concept? In a series of studies on reasoning about time, we demonstrate that gestures affect addressee's conceptions of time by keeping speech constant but altering gestures.

from Jamalian, A. and Tversky, B. (2012). Gestures alter thinking about time. Proceedings of the Thirty-Fourth Annual Conference of the Cognitive Science Society.

1: Circular vs. Linear Thinking: Diagram

Prior work (Kessell & Tversky, submitted) has shown that people are biased towards linear thinking. Participants were asked to diagram four-step cyclical or sequential processes. Most participants drew linear diagrams even for cycles. Expecting congruency between conception and visualization, Kessell and Tversky concluded that circular thinking is harder or less natural than linear thinking. Regarding time as a cycle is difficult because it requires abstraction from a particular instance of an event (i.e. a seed to a flower) to general classes of events. Thinking of time cyclically also requires ignoring the forward progression of time to thinking of time as traveling in a circle with no beginning, middle, or ending. Even though participants did not produce a preponderance of circular representations for cycles, they did comprehend circular diagrams (Kessell & Tversky, submitted). Could circular hand gestures prime cyclical thinking?

Method

Participants. 63 (40 female, 23 male) volunteers, mostly graduate students from Columbia University, participated.

Procedure and Design. All participants consented verbally to participate in the study. An experimenter said to each participant: "I will tell you about some events. I'd like you to think about these events and then construct a simple schematic diagram to convey them." One-third of participants were then told twice about one of the three cycles below:

Cycles
Seed to flower: • A seed germinates • A flower grows • The flower is pollinated • A new seed is formed
Events of a day: • Wake up • Go to work • Come home • Go to sleep
Clothing Cycle: • Take clothes out • Wear clothes • Wash clothes • Put clothes away

Figure 1: Cycle Stimuli

Each example was identically worded but accompanied by linear, circular, or no gestures. For the linear condition, the experimenter made 4 discrete slicing gestures right to left for the 4 stages in the spoken text. For the circular condition, the experimenter made 4 pointing gestures at 12, 9, 6, and 3 o'clock for the 4 stages in the spoken text. The right-to-left and counter-clockwise directions were from the experimenter's point of view so compatible with the subject's perspective. For the no-gesture group, the experimenter kept her hands in pockets.

Results

Coding the diagrams. Participants' diagrams were coded blindly as either linear, or circular. In circular (or repeating) diagrams the last event was connected back to the first, but not in linear (or ending) diagrams. Two of the diagrams from the circular-gesture condition, and 2 from the no- gesture condition were coded as "other" (see Figure 2).

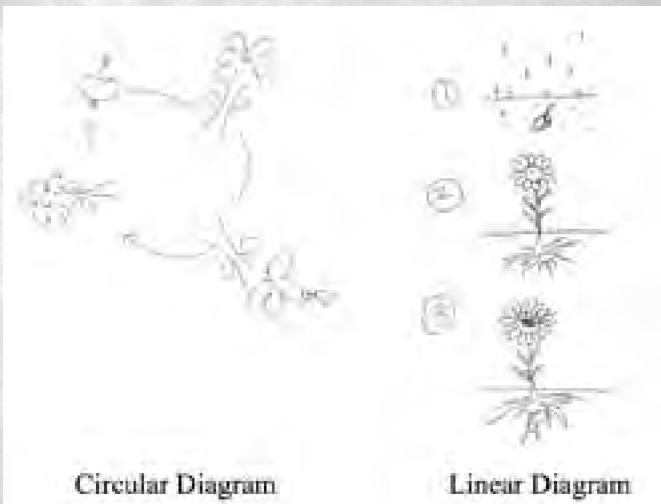

Figure 2: Examples of Diagrams

Findings. Of those who saw circular gestures, 66.7% drew circular diagrams. Of those who saw linear gestures, only 14.3% drew circular diagrams whereas 85.7% drew linear ones. As expected, of those who saw no gestures, 66.7% drew linear diagrams. Figure 3 shows the percent of linear, circular, and "other" types of diagrams for the three gesture conditions.

The form of gesture participants saw influenced the diagrams (excluding "other"

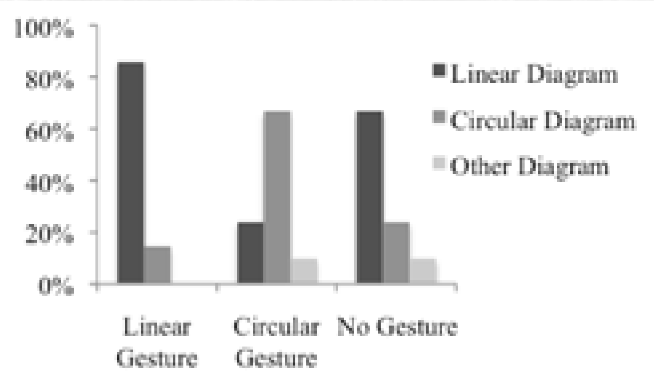

Figure 3: Proportion of linear, circular, and "other" diagrams by gesture conditions

diagrams) they drew; in a log- linear analysis, the two-way association between gesture condition and diagram type was significant, $x^2(2)=17.668$, $p=.000$.

Post-hoc analyses showed significant effects of circular vs. linear gesture, $x^2(1)=16.851$, $p=.000$, and circular vs. no-gesture, $x^2(1)=10.556$, $p=.001$, on diagrams. No significant differences were found for linear vs. no-gesture conditions, $x^2(1)=0.902$, $p=.342$. The number of circular diagrams was significantly higher than the number of linear diagrams in the circular-gesture condition, $x^2(1)=4.439$, $p=.035$. As expected, the number of linear diagrams was significantly greater than the number of circular diagrams in the linear- gesture, $x^2(1)=11.872$, $p=.001$, and no-gesture conditions, $x^2(1)= 4.439$, $p=.035$.

Discussion

Gestures had powerful effects on people's diagrams of events in time. People were asked to diagram a cyclical sequence of four events. Without gestures, a majority of participants drew linear diagrams. However, with circular gestures, a majority drew circular diagrams. If the way people diagram reflects the way they think, and there is considerable evidence for this (e. g., Tversky, 2011; Tversky, et al., 2002), then we can conclude that gestures affect the way people think about temporal events. However, it could be argued that participants copied the diagram the experimenter drew in the air. The next study obviates that objection by asking participants to make inferences.

2: Circular vs. Linear: Next Step

If seeing circular gestures induces cyclical thinking about time, then when participants are asked what comes after the "last" step they should tend to respond with the "first" step. This tendency should be reduced if linear gestures promote linear thought.

Method

Participants. 60 volunteers, mostly graduate students from Columbia University participated in this study.

Procedure and Design. The procedure and design were the same as the previous experiment except that the no-gesture condition was eliminated, only the seed cycle was used, and instead of being asked to produce a diagram, participants were asked: "What comes after the new seed forms?"

Results

Coding. Participants' answers to the question "what comes after?" were coded as linear or circular. Circular answers included repeating the first or any other stage and saying words such as repeating and cycle. Any other answers, such as "that was the last stage," "nothing," or "a fruit" were coded as linear.

Findings. In the circular gesture condition, 90% responded with circular answers, but in the linear gesture condition, only 60% responded circularly (Figure 4).

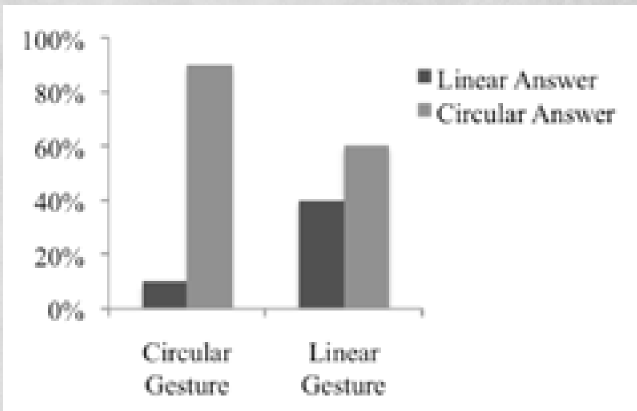

Figure 4: Proportion of linear and circular answers for each gesture condition

In a log-linear analysis, the two-way association between gesture condition and answer type was significant, $x^2(1) = 7.595$, $p=.006$. Interestingly, 30% of those who answered circularly in the linear gesture condition seemed unsure about their answers as they answered with a question tone.

Discussion

The previous experiment had shown effects of gesture form on diagram form. Here, we found effects of gesture on inferences. When asked "what comes after?" once hearing the last of four stages of a cycle, participants who saw circular gestures were far more likely to respond with the first or subsequent step of the cycle than those who saw linear gestures. Will gesture affect other kinds of thinking about time?

3: Perspective: Moving Ego/Time

The first two experiments showed that circular gestures promoted cyclical conceptions of time. The next experiment asks whether gestures can bias perspectives on time.

When people are asked "Next Wednesday's meeting has been moved forward two days; when is the meeting now that it has been rescheduled?" half say Friday, and half say Monday (Boroditsky, 2000; McGlone & Harding, 1998). Those answering Friday see themselves as moving through time, taking an ego-moving perspective. Those who answer Monday see themselves as stationary and time as moving past them, taking a time-moving perspective (Boroditsky, 2000; McGlone & Harding, 1998; McTaggart, 1908). In a series of clever experiments, Boroditsky & Ramscar (2002) showed that although people have strong intuitions about which answer is correct, their answers change dramatically depending on how recently they have moved or seen movement in space. For example, people who have just landed at an airport are more likely to take an ego-moving perspective than those waiting to meet passengers. People sitting still but watching things move are more likely to take a time-moving perspective. Will seeing actions in space, notably gesture, have similar effects on temporal perspective taking?

Method

Participants. 40 volunteers (25 female, 15 male), mostly graduate students from Columbia University participated in this study.

Procedure and Design. All participants consented verbally to participate in the study. While standing side by side, an experimenter told each participant: "Next Wednesday's meeting has been moved forward two days. What day is the meeting, now that it has been rescheduled?"

Participants were divided into two conditions: (1) forward sagittal gesture, and (2) backward sagittal gesture. In both conditions, the experimenter made a slice in the space in front of her body, with her palm facing her, while saying "next Wednesday's meeting", and then moved her hands away from her body for the forward-gesture, and towards her for backward-gesture condition while saying "has been moved forward". Note that participants and experimenter had identical points of view.

Results

The majority of participants who saw the forward gesture answered that the meeting was moved to Friday whereas the majority who saw the backward gesture answered that the meeting was moved to Monday (Figure 5).

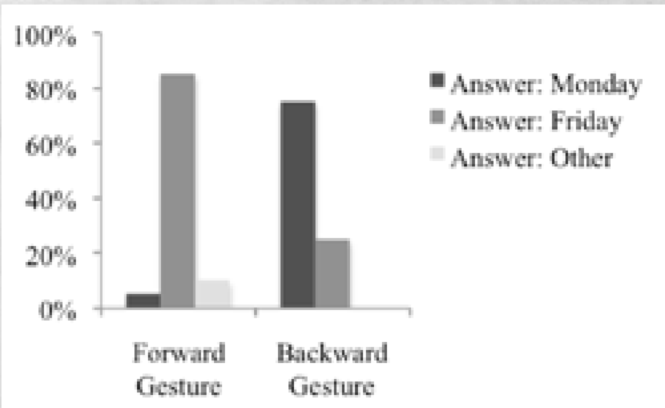

Figure 5: Proportion of participants answering "Friday" and "Monday" in each gesture conditions

One participant answered “not sure” and another, “Based on your gesture I’d say Friday, but based on your words, Monday”; these were coded as “other” and not included in the statistical analysis. In a log-linear analysis, the two-way association between condition (forward versus backward sagittal gesture), and answer type (Friday versus Monday) was significant, $x^2(1)=21.510$,

Discussion

When people are told that Wednesday’s meeting was moved forward two days and asked when the meeting is now, half spontaneously take an ego-moving perspective, answering Friday, and half take a time-moving perspective, answering Monday (e. g., Boroditsky, 2000; McGlone & Harding, 1998; McTaggart, 1908). Actually moving in space biases respondents toward the ego-moving perspective and watching movement from a stationary position biases the time-moving perspective (Boroditsky & Ramscar, 2002). Here, we found that observing representational actions, namely, gestures, also dramatically affected temporal perspective-taking. The experimenter first established a reference point for Wednesday in front of her body. When she gestured in a frontwards direction away from her body, a majority of participants responded that the meeting was moved to Friday, taking an ego-moving perspective, and when she moved her hand in a backwards direction towards her body, a majority of participants responded that the meeting was moved to Monday, taking a time-moving perspective.

Notably, the gestures were along the sagittal front-to-back axis of the body. For English speakers, the ego is the reference point, with future in the front of ego and the past behind (Cooperrider & Nunez, 2009). Here, the experimenter made a new reference point by placing her hand in front of her body saying “Next Wednesday’s meeting,” so the reference is Wednesday rather than the ego. Then, the experimenter moved her hand along the axis either to the front of the reference point or to the back of the reference point with respect to the body. There is another possible account for the effects of the gestures, and some participants could have adopted one, some the other. Participants could have taken an external or calendar perspective, with the saggital axis as a timeline and Wednesday as the reference point, with later events away from the body and the earlier events closer to the body. Either way, the gestures disambiguated the language and determined participants’ responses.

4: Parallel vs. Sequential Thinking

So far our experiments have shown that gestures alter the way people think of a sequence of events in time. Yet in life, people often have to keep track of events that happen simultaneously, a task that can be difficult (e. g., Bauer & Johnson-Laird, 1993). In one study, students had difficulties comprehending that the two middle steps of a four-step procedure for writing a paper were simultaneous. A diagram showing the simultaneous events side-by-side helped (Glenberg & Langston, 1992). Like diagrams, and in contrast to serial language, gestures can organize things in space and show simultaneity (e. g, Tversky, Heiser, Lee, & Daniel, 2009). Might gestures help people think about parallel events in time?

Method

Participants. 60 volunteers, mostly graduate students from Columbia University participated in this study.

Procedure and Design. After receiving verbal consent for participation, an experimenter said to each participant: “I will tell you about a procedure, and then ask you a quick question about it”. Participants were then told the following procedure for writing a paper (based on Glenberg & Langston, 1992): “There are four steps to be taken when writing a paper. The first step is to write a first draft. The next two steps should be taken at the same time: One of the steps is to consider the structure; the other step is to address the audience. The final step is to proofread the paper.”

Participants were divided into two

conditions: (1) parallel- gesture, and (2) sequential gesture. For the parallel-gesture condition, the experimenter made a slice in the air in front of her face, with her right hand palm facing down, while saying "the first step is to write a first draft". Next, she made two slices with two hands simultaneously below her first hand gesture, while saying "the next two steps should be taken at the same time". Next, she moved her right hand back and forth from her wrist, in place, with her left hand still in the air, while saying, "one of the steps is to consider the structure". Then, she reversed those hand actions while saying, "the other step is to address the audience". Next, she took away her left hand and made a slice with her right hand facing down, below its previous spot, while saying, "the final step is proof read the paper." For the sequential-gesture condition, the experimenter made 4 slices with her right hand facing down, from top to bottom on a vertical line in front of her, for the 4 steps in the procedure.

After hearing the description twice, participants were asked: "Here is the question now: According to the procedure I just gave you, what should one do immediately after writing the first draft/ before proof reading the paper?" Half of the participants in each condition were asked about steps after writing the first draft, and the other half were asked about steps before proof reading the paper.

Results

Coding. Participants' answers to before/ after questions were coded as sequential, parallel, or other. Answers that mentioned only one of the two steps (considering the structure or addressing the audience) were coded as sequential. Answers that mentioned both steps were coded as parallel. Any other answer was coded as "other".

Data analysis. In the parallel-gesture condition, 76.7% mentioned both steps while only 56.7% in the sequential- gesture condition gave parallel answer. Forty percent of participants in the sequential-gesture condition but only 10% of subjects in the parallel-gesture condition mentioned a single step (Figure 6). Four participants in the parallel- gesture condition, and one in the sequential-gesture condition mentioned other steps and were excluded from the data analysis.

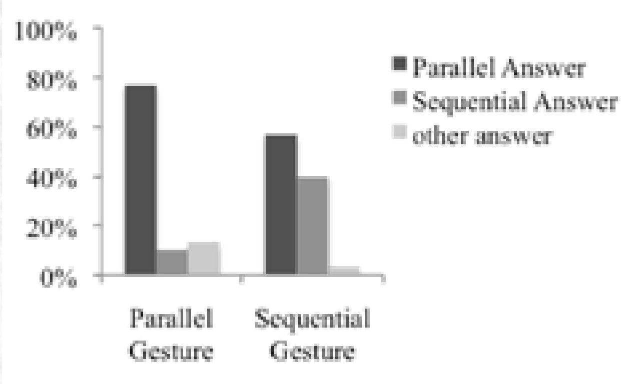

Figure 6: Proportion of parallel, sequential, and "other" answers in parallel- and sequential-gesture conditions

In a log-linear analysis, the two-way association between gesture type and answer was significant, $x^2(1)= 6.276$, $p=.012$. However, the two-way association between question type (before vs. after) with answer (parallel vs. sequential) was not significant, $x^2(1)= 1.988$, $p=.159$, nor was its three-way association with condition (parallel- vs. sequential-gesture) and answer type, $x^2(1)= 0.114$, $p=.736$.

In addition, significantly more participants in the parallel- gesture condition gave parallel answers than sequential answers, $x^2(1)= 17.447$, $p=.000$. There was no significant difference between number of parallel and sequential answers in the sequential-gesture condition, $x^2(1)= 0.866$, $p=.35$.

Discussion

We have shown yet again that gesture influences how people think about time. Previous research (e. g., Bauer & Johnson-Laird, 1993) had shown that people find it difficult to conceptualize parallel events. Here we showed that gestures that indicate the parallel structure of events help people to reason about simultaneity of events.

General Discussion

One way that people think of events in time is through space, as dots, representing events, on a line, representing time. The line can be regarded as straight, a linear sequence of events, perhaps, as in most narratives, having a beginning, middle, and end. For events that repeat, like the parts of the day or the seasons of the year, the line can be regarded as circular. Simultaneous events can be thought of as parallel lines. The mental time lines typically have a spatial orientation and a perspective. When straight, that line can be regarded as horizontal in reading order, vertical in top-down order (Boroditsky 2001; Tversky, et al., 1996) or saggital from front to back (Cooperider & Nunez, 2009). Thinking and talking about time use target and reference events and a perspective on time, just like thinking and talking about space (e. g., Talmy, 2000). People can take an external perspective on the line, as in looking at a calendar or a timeline, much like taking an overview of an environment or looking at a map. Alternatively, they can see themselves embedded in time just as they can see themselves embedded in space. The ego can serve as a reference point, located on the timeline. In the ego-moving perspective, ego moves along events on the timeline; in the time-moving perspective, ego is stationary and events move past ego. Either way, changes in time are conceived of as actions in space. If changes in time are conceived of as actions in space, then actions in space might affect conceptions of time. Indeed, Borodtisky and Ramscar (2002) showed exactly that, that moving in space or watching movement in space alters temporal perspective. Here we found that information in gestures but not in speech could also alter people's conceptions of time. Circular gestures biased thinking about a series of events as a cyclical rather than linear. Frontwards gestures away from the body biased taking an ego-moving perspective on time and gestures toward the body biased taking a time-moving perspective. Finally, gestures that traced parallel paths helped people think about simultaneous events.

Why do gestures have such powerful effects on thought? Many gestures are miniature actions in space that represent actual actions. For representing time, the gestures traced temporal paths in space, and indicated specific events along the paths. In representing paths as lines and events as dots, gestures are like diagrams (Tversky, 2011; Tversky, et al., 2009). The set of gestures both abstracts a model of time and shows it, a more direct way to communicate than purely symbolic speech.

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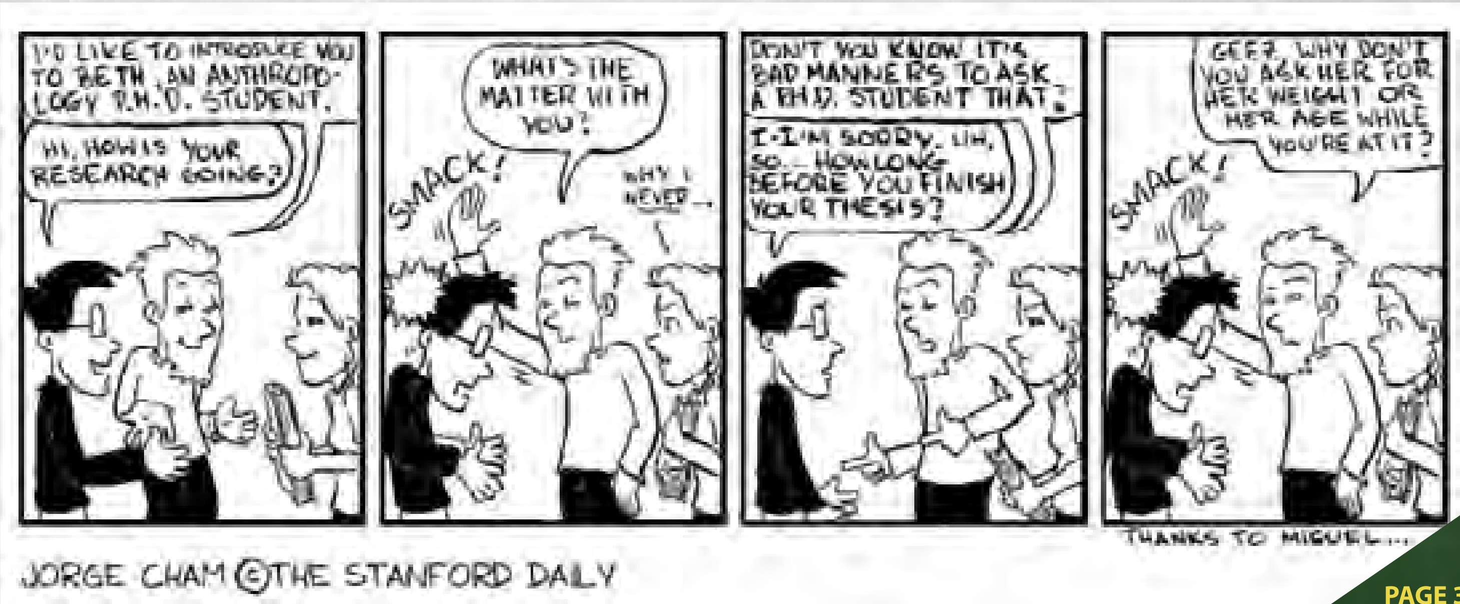
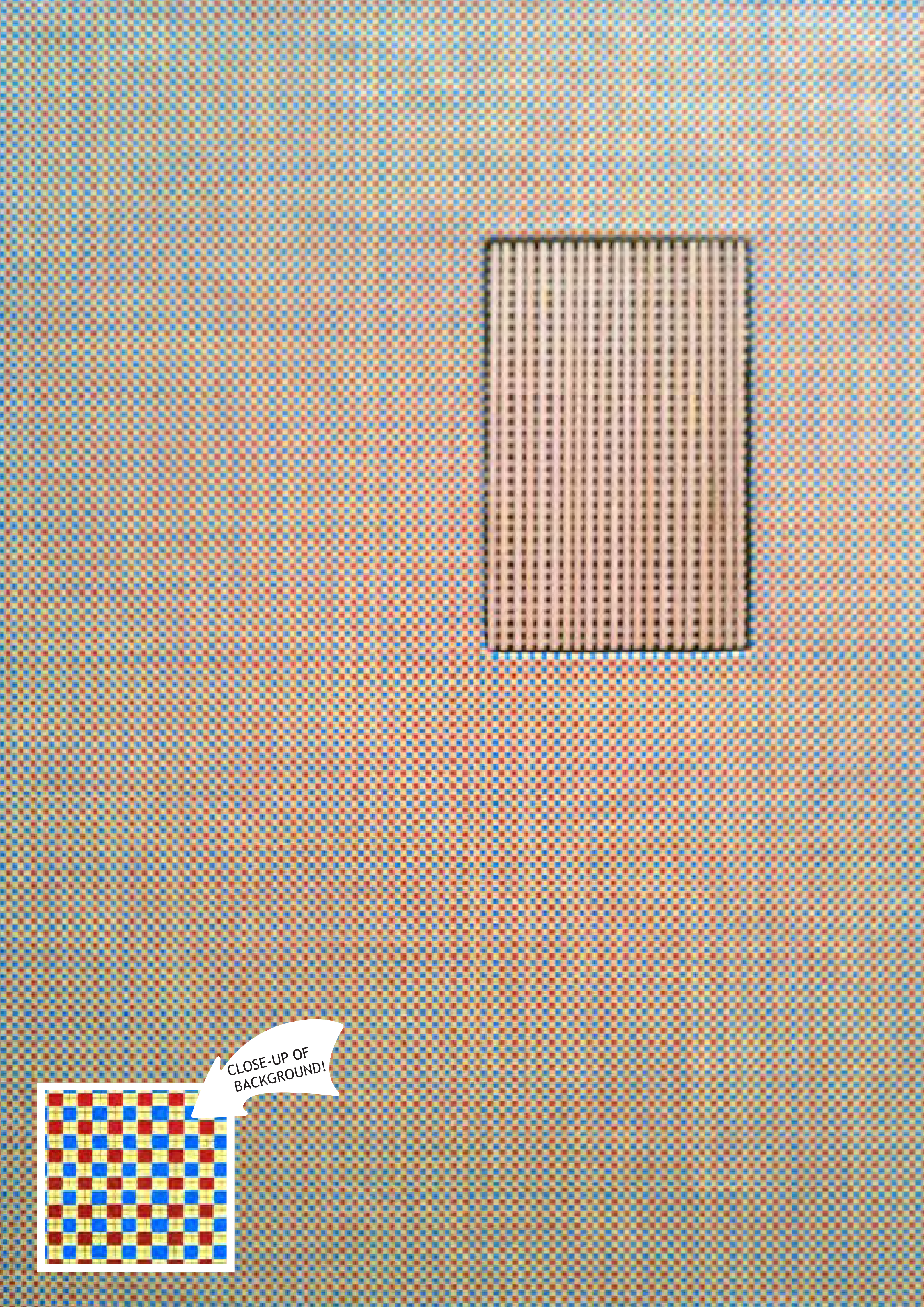



CLOSE-UP OF
BACKGROUND!

SEGMENTING & CONNECTING

“How do we describe our perceptions and cognitions and weave them together into a narrative or stor, and in particular, how do we do this in our depictions?” That’s the question Professor Barbara Tversky asks in her course Visual Explanations that delves into the way that depictive devices can convey so much information at a mere glance.

Visual explanations have developed over thousands of years of human civilization: From the depictive walls of ancient Egyptian tombs that show step-by-step how to make bread to the step-by-step diagrams that help us assemble our furniture. In comics books and graphic novels, these devices dig deeper developing narratives that twist and turn. Plots unfold, more less through discrete frames set scenes and depict the manners and actions of the story.

Professor Tversy

At the extremes, we can think of life as either a sequence of still images or as a constantly changing continuum. In Scott McCloud’s highly praised book, “Understanding Comics” (left), he analyzed the types of transitions that occur from one frame on the page to another. Japanese comics, for example, use more *aspect to aspect* transitions to communicate the dynamics of a scene. Showing many different aspects within the scene creates different responses in the reader/viewer. That inspired Professor Tversky and Tracy Chow to look further into this phenomenon.

It should first be said that Tversky and Chow failed to replicate McCloud's effects on transitions from frame to frame. Consequently, they decided to focus on what happened *within* each frame, specifically on whether the depictions emphasized action or set a broad scene.

They proposed two factors that might affect how much action would be conveyed in frames, language and culture. They selected comics that were aimed at teen-aged boys and were popular and widely mass-produced (i.e., the medium was inconsequential to the particular artist).

Next, they picked four stories from four different cultures (American, Japanese, Italian and Chinese) and then presented specific frames surveyed from different way-points in each story (the first page, ¼, ½, ¾, last page) to two groups of raters (American or native-Japanese). Any wording was removed from all of the illustrations and participants were then asked to rate the frames on a scale of 1 to 4 as either depicting action (4) or setting a scene (1). By surveying different points throughout each work, Tversky and Chow were also able to evaluate any differences or patterns in overall narrative structures between the works.

Whorf Worf

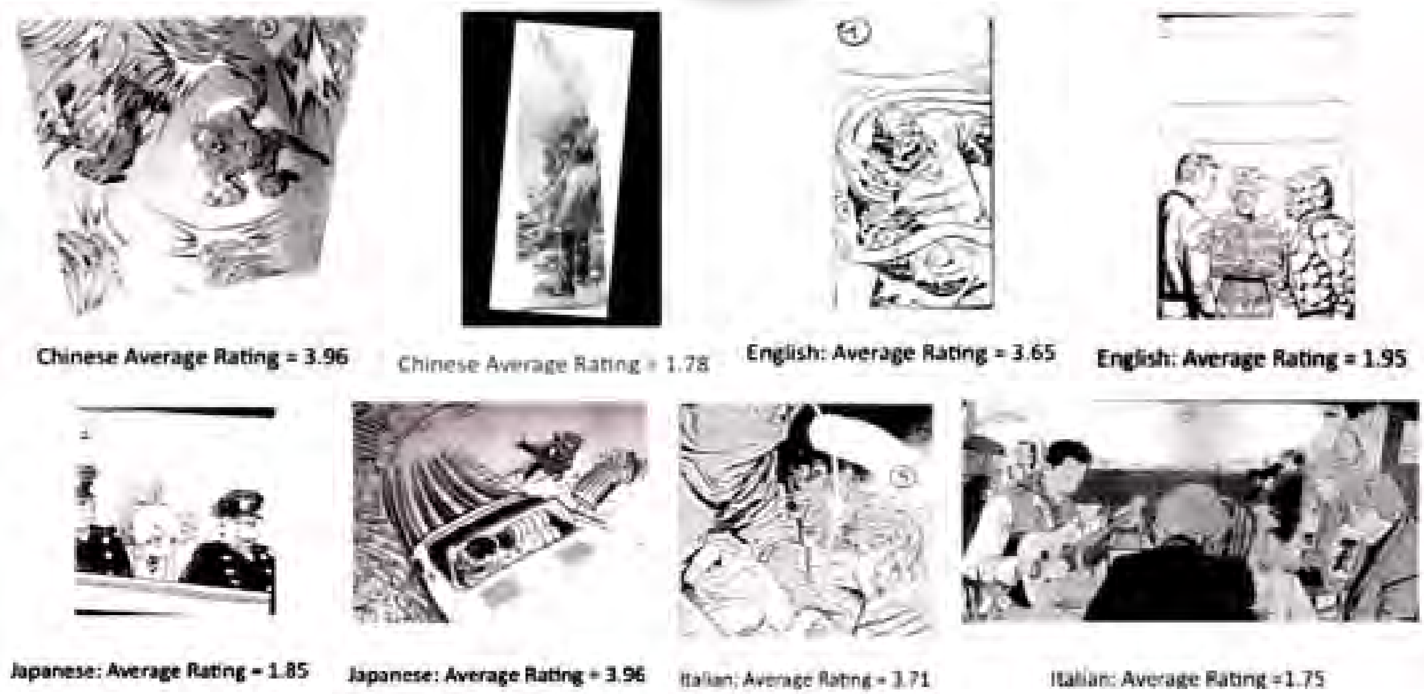
Their research addressed two questions: (1) Do languages with more and richer verbs of motion depict more action? (A twist on the Whorfian hypothesis), and (2) Do cultures that are more interrelated depict more action?

The first hypothesis was based on the work of Leonard Talmy that identified languages as being either "manner" or "path" languages. Languages like English, German and Chinese have many verbs that express manner of motion. For instance, people can sashay, swagger, slink, skip, stagger and stumble into a room, out of a room, up the hill, down the hill and around the hill. However, there are other languages like Japanese, the romance and Semitic languages that have almost no manners. In these path languages, there are very few verbs that convey manner of motion. Principally, the Latinate verbs allow you to enter, exit, ascend, descend and you can run. If you want to express any of these fancier things, you must do so in a gerund or some other part of speech.

Similarly, in manner languages, you can express a long pattern of motion like, "the rabbit scampered over the hill, under the bridge, across the meadow, into the cave, up the ladder, and so on all using one verb." But in the languages like Spanish and French you have to reinstate the verb and as a result, path languages tend to avoid these long patterns in literature.

3	8	9	1	5	2	4	7	6
5	6	7	8	4	3	2	9	1
1	4	2	6	7	9	8	5	3
7	1	6	5	9	8	3	2	4
4	5	3	2	6	7	1	8	9
9	2	8	3	1	4	5	6	7
8	3	1	7	2	6	9	4	5
2	7	4	9	3	5	6	1	8
6	9	5	4	8	1	7	3	2

Moreover, analyses of translations between the two types of languages found that long patterns of motion in English were frequently translated into static scenes in French and Spanish while static scenes in French and Spanish were often translated into English as long patterns of motion. Thus, speakers of languages with rich sets of verbs that express manner of motion more individualistic. Because most of the action in comics is between people, action turns out to be a powerful way to show interrelationships. For this reason, eastern comics should depict more action on average than western. Tversky and Chow selected comics from two manner languages,



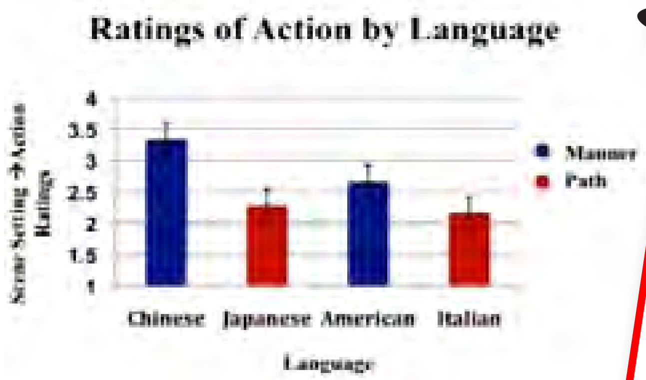
Chinese Average Rating = 3.96 | Chinese Average Rating = 1.78 | English: Average Rating = 3.65 | English: Average Rating = 1.95

Japanese: Average Rating = 1.85 | Japanese: Average Rating = 3.96 | Italian: Average Rating = 3.71 | Italian: Average Rating = 1.75

Chinese and English, and two path languages, Japanese and Italian. Note that the sample also included two eastern cultures China and Japan, and two western cultures, the US and Italy. This enabled assessment of the effects of both language and cultral depictions.

All four languages (Chinese, English, Japanese and Italian) had frames that were rated as having action and setting scenes. Chinese comics showed the most action, followed by English, Japanese and Italian, respectively. There were main effects for both language and culture.

First, the manner languages showed significantly more prevalence of action frames while the path languages showed significantly more scene setting frames. The language effects make sense because manner of motion will tend to depict action more. Another plausible

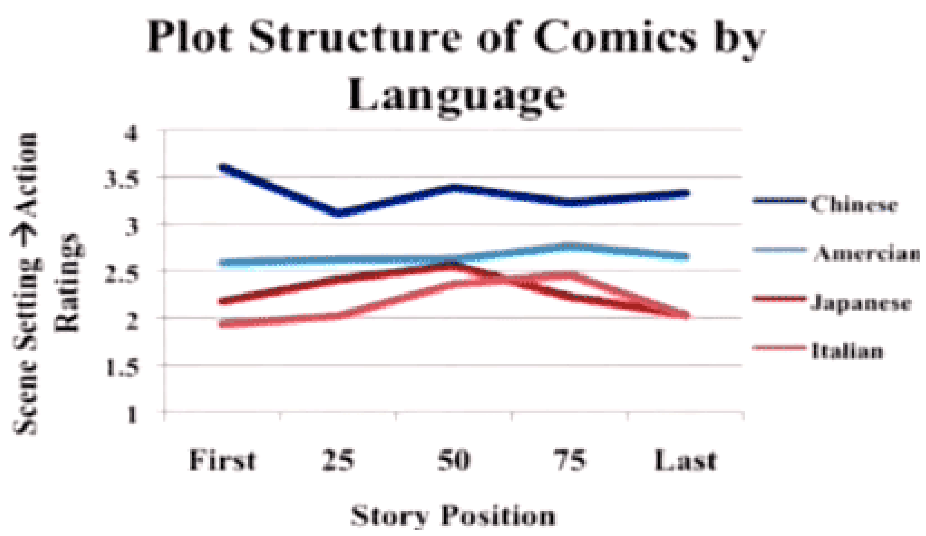


explanation includes that the writing of comics is thought out in language and might incline authors and illustrators to depict more action as a result.

Second, eastern cultures (Chinese and Japanese) showed higher scores than their respective western language counterpart. While this result seemed counterintuitive at first (i.e., we would expect more scene setting in eastern culture literature), further analysis concluded that the higher incidence of action in the eastern culture comics is a result of the fact that action is actually depicting relationships. Most action is someone doing something with someone else, or some type of interaction and makes sense in the scope of the collectivist idea.

There were not, however, any differences between Japanese and American raters.

Both groups assessed the frames depicted in the comics similarly. Another fourth analysis looked at story position averages (i.e., the prevalence of action versus scene frames and narrative structure) between manner and path languages and found that on the whole, path language displayed a more Aristotelean narrative structure where the action rises until about ¾ of the way through the story and the last quarter is spent resolving the conflicts.



Overall, visual narratives from diagrams to graphic novels often employ visual devices like frames, arrows, links, nodes. These are the visual vocabularies, the geometric elements of schematics that have formulate meaning in a larger gestalt within given contexts. They are visual means and devices used for breaking up time and space, depicting time and space and linking time and space to create meaning.

Since earliest days, humans have been depicting information and conveying our thoughts through pictures. Over time, the sophistication of our semiotics have developed into a rich array of technique that humans use to express themselves. Professor Tversky continues to explore these concepts in a number of classes here at Teachers College including *Visual Explanations* and *Spatial Thinking* in addition to continuing research with her students. If you'd like to explore more, you can contact Professor BarbaraTversky at:

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Perceptual & Propositional Encoding and Memory Retrieval of Paired-Associate Works of Art

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What do the earliest petroglyphs by the Aurignacians in the caves of France, the stylized engravings by Albrecht Dürer, the pointalist impressions by Georges Seurat and the abstractions by Adolph Gottlieb all share? They are communicative expressions of the complexities of our cognitions and our consciousness. For tens of thousands of years, human beings have developed increasingly sophisticated techniques of depicting the world. Visual art offers us complex stimuli from which we can explore how we derive meaning, feel emotion and become inspired to reflect and create. From the seemingly instantaneous percepts of our five senses, our brains and bodies combine stimuli into concepts that contribute to the gestalt of consciousness.

From Aristotle to Kant to Goethe and into modern day, Aesthetics has always been a key component to society and culture. As the Romantic period intertwined with Logical Positivism in the mid-to-late 19th century, Goethe's earlier proposal of a morphology of art based on biology and physics of form took root in the emerging "scientific method" of aesthetic phenomenology. In modern contexts, these scientific investigations have explored many of these phenomenae. In the case of visual cognition, researchers have utilized different methodologies and different types of stimuli that ranged from very simple to very complex.

Simple stimuli like lines, shapes, contrast gradients or contour drawings allow researchers to isolate behavioral responses and pinpoint more accurately the underlying neural substrates. The growing literature on the visual field deciphering reasons why different types of art can impact what we percieve and think about how we see the world.

The Artist, The Art, The Audience and *Seeing*

The genesis of a work of art is a process of visual conceptualization, production and analysis. It engenders a recursive relationship between the artists' perceptions and perceptions of those perceptions (Fry, 1909/1981; Gombrich, 1960; Seeley & Kozbelt, 2008). Visual artists play with ambiguity, eliminate elements, emphasize others, focusing attention and blurring boundaries. They employ the iconic and the unidentifiable as elements and strategic devices that take advantage of the flexible

Allison Faye

and adaptive nature of the perceptual system. But this is only half of the picture (pun intended). In the Berkelean (1710/2012) sense (i.e., do trees in the forrest exist...), art not only requires an artist but also a beholder.

In this dualism between the artist (as producer) and the audience (as perceivers), attentions are purposefully directed through the composition of both perceptual and semantic constructs; the resulting relationships are the cognitions of the perciever and what is "seen", as guided by the producer's art (Gombrich, 1960; Redies, 2007). Between the artist and the audience, there is a continuous discourse, oscillating between reflection and identification; the gestalt of art arises from the resistance and tensions created in the relationships between visual elements in the artwork (Bruner & Minturn, 1955; Kubovy & Pomerantz, 1981; Palmer, 1999; 2002; Redies, 2007).

Visual Elements: Percepts and Semantics

Visual elements are principally divided into two categories: (1) percepts and (2) semantics. Kahnemen and Treisman (1992) refer to the former as perceptual objects— the essential units of information processing, generally considered as "bottom-up" (Tverksy, 2005). In art, these include rudimentary attributes of our visual systems like line, color, hue, shade, contrast, occlusion, edges, and shape (Kandinksy, 1926/1979; Redies, 2007).

From the "top- down," the processing of semantic information is conceptualized as starting with more complex cognitive schemas and then breaking them down into simpler structures like objects (Gombrich, 1950; Redies et. al.; Fei-Fei, Iyer, Koch, & Perona, 2007). For example, the recognition of the central figure in an Impressionist painting as a woman, and a mother, in addition to a smaller figure, related as her child, is semantic interpretation. Closer inspection, of course, would reveal only pigments of paint, varying colors, abutted against one another, different line lengths and widths. Yet, we also see the objects and the overall scene depicted by the artist.

Visual perception is not a static morphology determined by set principles of vision, but rather an active and integrative process of inferencing (Bruner, 1955, 1957; Goodman, 1984). It is the complimentary relationship between these two processes, the perceptual and semantic, that occur in tandem via parallel processing networks in the brain (Ungerleider & Brody, 1977; Ungerleider & Mishkin, 1982; Goodale & Milner, 1992; Turnbull, Denis, Mellet, Ghaem, and Carey, 2001). When contextual information combines with stimulus information, we see pattern (Massaro, 1979) that becomes a complex visual scene that's recognizable (Biederman, Glass and Stacy, 1973); this, combined with the intention of the artist, is the gestalt that makes art uniquely impactful and worthy of investigation.

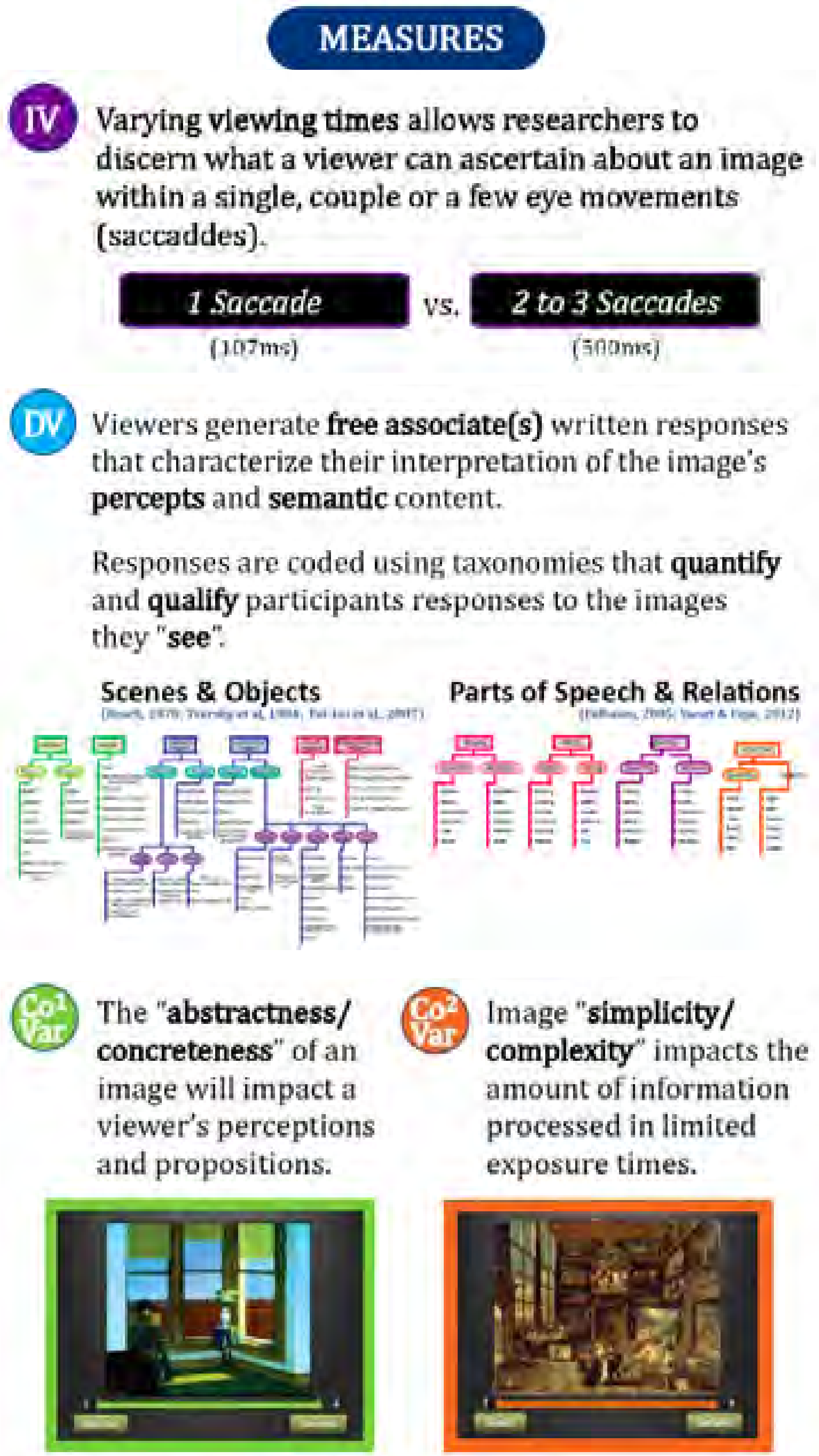
The Gestalt Goodness of Art

Admittedly, there is good art and not-so-good art. The "goodness" of the gestalt (Wertheimer, 1923; Arnheim,1986) is collectively determined by an artwork's capacity to capture attention, engage the imagination and impress upon one's cognition (Gruber, 1989; Csikszentmihalyi, 1996; 1999). The

technical articulation, compositional symmetry and contextual salience of a work mediates the relationship between the artist and the viewer and moderates the visceral experience. More abstract works are open to interpretation and harder to identify.

Paivio (1965) investigated participants' learning of words presented as paired-associates that varied by their levels of abstractness or concreteness. Nouns (either concrete, e.g., pencil, coffee, women; abstract, e.g., idea, moment, soul) were paired together in four combinations: a concrete followed by another concrete (CC), a concrete followed by an abstract (CA), an abstract followed by a concrete (AC) and finally two abstract nouns (AA). The words were pre-rated (by separate pools of participants) for their level of imagery (*I*, defined as sensory imagery- the ability to arouse an image- using an ordinal scale ranging from "very easy" arousal of images to "very difficult"), meaninfulness (m, operationalized by the number of free associates generated) and familiarity (f, quantified using a 9-point likert scale). The dependent measure was participants' abilitiy to recall the target associate (i.e., total number of correct targets recalled) when a given stimulus (the associate word) was provided.

Results indicated that recall was highest for CC pairs followed by CA, AC and AA successively. Additional measures of I, m, and f followed the same trend, with scores highest for concrete nouns and lower for abstract. Most notably, correlations of *I*, m, and f were stronger for the stimuli than for the targets, supporting the importance of how information is encoded. Furthermore, *I* was the most distinct of the three covariates, and Paivio (1965) suggest that this is due to both the strong linkages available between concrete stimuli as well as the possibility of cognitive differentiation. The more linkages that participants formed (i.e., the more they differentiated amongst associates) the better their recall.



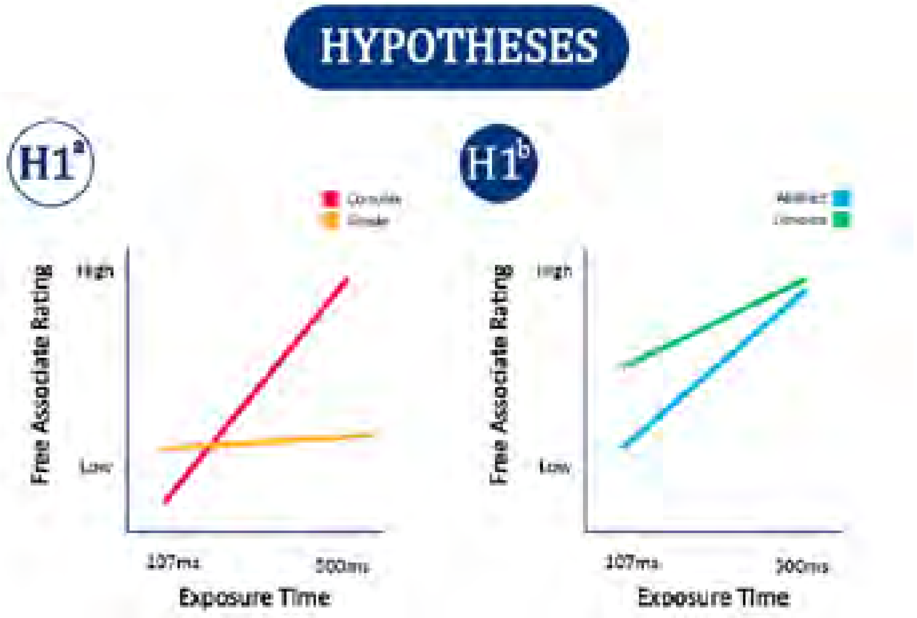
For the current study using fine-art images, researchers anticipate even stronger results. Abstract works of art, and art in general, are immediately imagery-based. The amorphous nature of abstract words like "idea" that have less imaginative (i.e., less object-oriented associations) are more difficult than remembering places or things, or pictures of them.

Research over the last three decades has demonstrated that human's ability to remember images that they've seen numbers in the thousands (Brady, Konkle, Alvarez, & Oliva, 2008; Bower, Karlin, & Dueck, 1975; Standing, 1973)—corroborating the old addage "a look [picture] is worth a thousand words." (Barnard, 1921).

Thus, the question is whether the same discrepancy exists betwen concrete and abstract images? Is there an optimum level/ratio of abstractness to concreteness in images that empowers the broadest cognitive interpolation without losing specificity?

The Potential for Rich Responses to Fine Art

In cognitive terms, it is about our "capacity to encode, store, and retrieve information" (Tulving, 2000). The founder of American psychology, William James (1890), distinguished between the "conscious present" of our primary memory and the information stored beyond conscious awareness, or secondary memory. In a highly figurative work of art (i.e., with recognizable semantic elements), the underlying perceptual properties can captivate attention long after the viewer has identified the *gist* of the scene (Chun & Jiang, 1998; Redies, 2007). Conversely, from a highly abstract work of art (i.e., with identifiable perceptual elements), the viewer can develop interpretive semantic associations that may remain dissociated from recognizable concrete objects and are instead expressed as emotive responses and/or qualia (the quality of an experience). The gestalt of the experience of art represents going beyond recognition, toward inference, judgment and abstract conceptualizations of relationships.

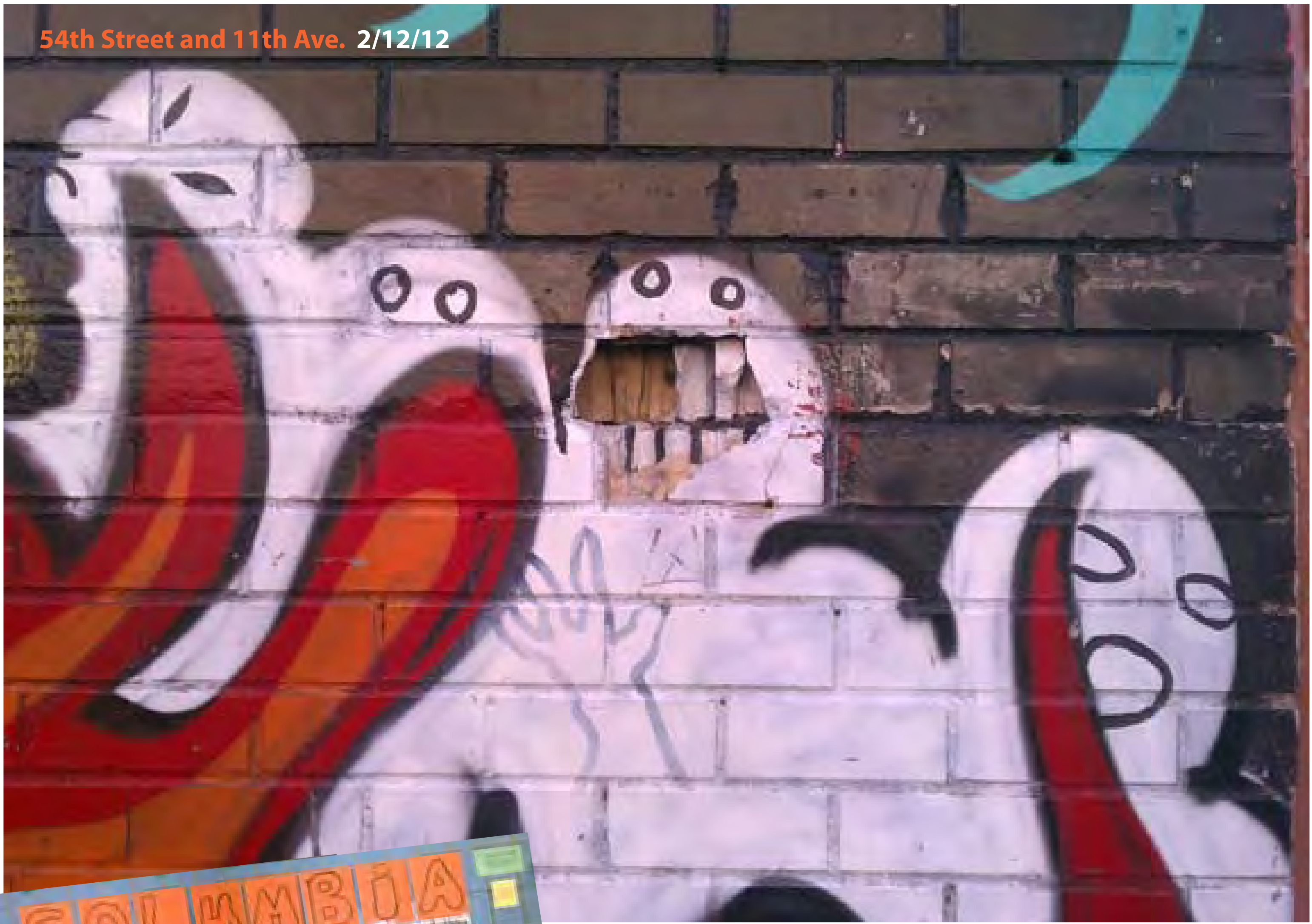


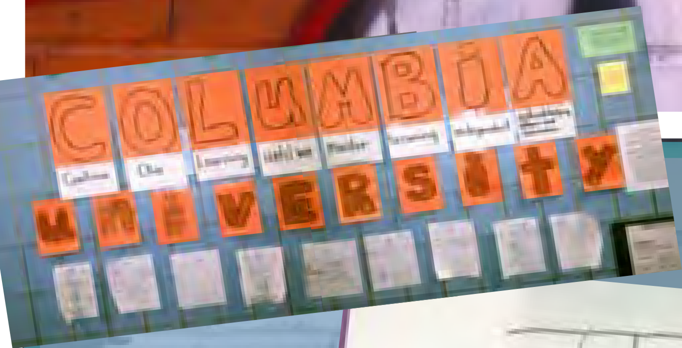
Complex images will elicit <u>more free associates</u> (quantity and quality) at **500ms exposure** times **than simple images** while **simple images** will elicit <u>more free associates</u> at **100ms exposures** times **than complex images**.

Concrete images will elicit <u>more free associates</u> (quantity and quality) at **100ms exposure** times **than abstract images** while **abstract images** will elicit <u>more free associates</u> at **500ms exposures** times than **concrete images**.

According to Gick and Holyoak (1983), deciphering these relationships is mediated through human beings' capacity for analogical reasoning; that is, our ability to apply the heuristics of a familiar problem space to a novel one by finding the similarities and differences between the two. Research on perception and recognition of various visual stimuli, though once thought to be most efficient when two stimuli differ significantly, is actually much more complex. In certain instances when stimuli are highly similar, participants ability to perceive and recognize stimuli is actually enhanced depending on the circumstances of encoding and retrieval (Bahrick, Clark, & Bahrick, 1967; Kintch, 1970; Bower & Glass, 1976; Kahneman, Treisman & Gibbs, 1992; Treisman, 1991; Tulving, 1981). In art, the process of inferencing from perceptual cues is a continuous process of conceptualization rooted in identification and categorization (Bruner, 1950) that either cleanses the stimulus of distracting detail or intensifies its characteristic features and asymmetries (Arnheim 1974; Goldmeier, 1941; Wulf, 1922).

The current study is designed to explore the multifarious relationships between stylistically different types of works of art (ranging from concrete representations of recognizable objects/schemas to abstract constructions subject to interpretability) and how various combinatorial pairings of works of art (i.e., concrete-concrete, concrete-abstract, or abstract-abstract) can affect the viewer's perceptions, semantic associations and memory.





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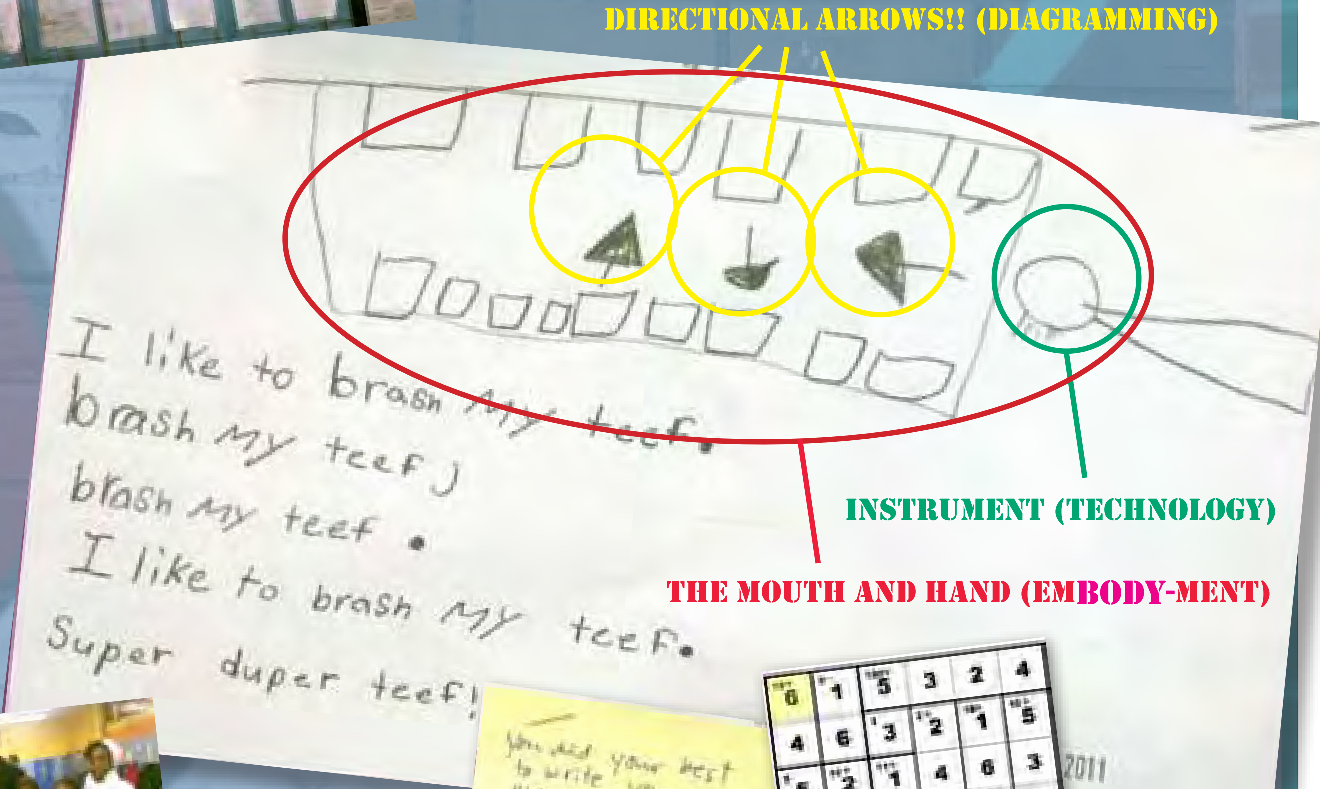

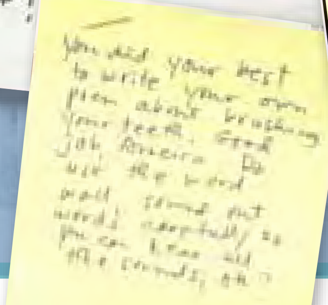

6	1	5	3	2	4
4	6	3	2	1	5
5	2	1	4	6	3
1	5	4	6	3	2
2	3	6	5	4	1
3	4	2	1	5	6