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Tel: (619) 534-2536 • E-mail: info@crl.ucsd.edu • WWW: http://www.crl.ucsd.edu/newsletter

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FEATURE ARTICLE

Blending and Your Bank Account: Conceptual Blending in ATM Design

Barbara E. Holder
Department of Cognitive Science
University of California, San Diego

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Please forward correspondence to:

Paul Rodriguez, Editor
Center for Research in Language, 0526
9500 Gilman Drive, University of California, San Diego 92093-0526
Telephone: (619) 534-2536 • E-mail: editor@crl.ucsd.edu

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Blending and Your Bank Account: Conceptual Blending in ATM Design

Barbara E. Holder
Department of Cognitive Science
University of California, San Diego

Abstract

In this paper I explore Fauconnier and Turner's (1998) conceptual blending as an evaluative technique for user interface design. Conceptual blending theory offers a rich model that may account for meaning construction and meaning elaboration in design. Blending has been used previously to analyze jokes (Coulson, 1995), metaphor (Fauconnier & Turner, 1998), and Hebrew verb morphology (Mandelblit, 1997). I apply blending theory to unpack the conceptual structure of an everyday artifact, (the automated teller machine), and discuss how that structure is reflected in the design and use of the ATM. The ATM is described as a blend of computing and banking domains with its own properties and conceptual extensions. In the analysis I investigate how task-level representations and operations change within the ATM blend and how these changes introduce temporal complexities into the blend. The debit card and check card are examined as conceptual extensions and an evolution of the ATM blend. I also address some conceptual changes the blend introduces to traditional banking schemas and the changes in social practices of banking. Finally I propose blending as a productive usability evaluation technique.

INTRODUCTION

Fauconnier and Turner's (1994, 1998) notion of conceptual blending may be used to analyze cognitive aspects of design and to evaluate the usability of technological artifacts. Applying conceptual blending theory to evaluate user interfaces is a novel direction for blending theory, but has value as a usability assessment technique because it exposes the underlying conceptual structure of the interface design. Design blends are constructed from the projections and mappings of elements from two or more source domains into the design and use of an artifact that yields new task representations, conceptual understandings, and activities. Once the conceptual structure is identified designers may examine mappings and projections that are clumsy and likely to give users difficulty interacting with the interface. I selected the automated teller machine (ATM) for my illustrative example of a design blend because it is an everyday artifact that is familiar to many people and the blend is theoretically interesting.

Mack & Nielson (1995) define the concept "usability" as the end user's perception of how easy a system is to learn, how efficiently it may be used, and how pleasurable it is to use. The end user may find an interface difficult to use for a variety of reasons. This paper addresses aspects of usability that relate to ease of learning and use, which I believe to be the strengths of applying conceptual blending theory to design.

Conceptual mappings that are easily understood in design have been expressed as “semantic directness” (Hutchins, Hollan, & Norman, 1986). The concept of directness implies that ease of use is directly measured in the commitment of cognitive resources required to understand and use an interface. Designs that make the content of an interface meaningful without extensive interpretation are favorable and semantically direct. One way to enhance the sense of directness is to exploit the end user's background knowledge to make mappings obvious and the interface transparent. "Knowing the user" is a hallmark of usability evaluation (Baecker et al, 1995), but it might be better stated as 'know what the user knows' and this is where conceptual blending theory can offer the most value. Cultural knowledge, mental models, and background knowledge all contribute to what a user needs to know to operate an ATM. The user brings his knowledge to the design blend and may apply it to understand new task representations and to perform novel tasks within the blend.

One example of blending in design is the Apple Macintosh desktop user interface that structures the interface to mimic an office desktop. The electronic desktop has icons representing a desk, files, folders, a trash can, pens, and so on. The design blends structure from both the computing domain and the office domain to create an integrated autonomous user interface. The user makes sense of the blend by recruiting knowledge from each domain. The set of possible mappings is physically constrained by the desktop and the conceptual limitations of what is known to be possible in office environments. The metaphor connects the user to the system by setting up the target domain in terms of a source domain the user already understands. Metaphors are popular among designers because they structure aspects of the target interface in terms that are commonly understood aspects of the source domain (Erickson, 1990). While some design examples may be explained at a basic level using analogy and metaphor, such as the desktop, conceptual blending theory offers a richer model that also accounts for meaning construction and meaning elaboration. Design blends exhibit properties similar to those of conceptual blends in language; there is emergent structure, elaboration, and new conceptions.

Designers often blend conceptual structure from a domain familiar to the user, with physical and operational structure from the computing domain to create a novel interface. These design blends can change the nature and structure of an activity. Even general knowledge acquired through elementary use of computers offers enough operational knowledge for users to make sense of an automated teller machine. Conceptual blending in technology has consequences for how we think about a tool, how we use it to perform an activity, and its adaptation to novel uses.

I begin by describing the Automated Teller Machines (ATM) as an example of conceptual blending in design. I describe the blend and show how task-level representations and operations are changed within the blending framework. Then, I discuss how the ATM has contributed to conceptual changes in our traditional banking schemas. I also discuss conceptual extensions and conceptual evolution to the ATM blend through the design and use of debit cards and check cards. I conclude with ideas on applying conceptual blending theory to successfully guide design and improve usability assessment techniques.

A BLEND OF ACTIVITY

A blend is a mental space construction that inherits partial structure from two input spaces and a generic space (Fauconnier, 1997). The generic space for the ATM blend is the exchange of products and services through interaction. Source domains are banking and computing, which combine to structure the ATM blend. Each source shares abstract structure from the generic space and the other source to define cross-domain mapping between source domains (Figure 1). The figures presented throughout this paper are based on Fauconnier's (1996) style of illustrating blends. Both source spaces share task structure that support interactive processes. Monetary accounts correspond to computer accounts, access to a bank account requires a Personal Identification Number (PIN) and a password for access to computer accounts. Conceptually accessing a bank account is similar to accessing a computer account they both exist in the abstract, but are not themselves physical, they have physical properties that are manifest in money and files.

Generic: Interactive Exchange
Exchange of goods, services, information
Interaction

Source 1: Banking	Source 2: Computing
Storage/Retrieval Money	Storage/Retrieval Bits
Human-human interaction	Human-computer interaction
Checking/Savings Accounts	User Accounts
Financial Services	Application programs
PIN	Password

ATM Blend
Storage/Retrieval Money, account information
Human-computer interaction
Bank account
PIN

Figure 1. Bank and Computer Cross-Domain Mappings

The ATM is a physical machine with partial structure from each of the inputs as well as its own unique structure. The ATM blend inherits conceptual structure from banking and operational structure from computing that makes autonomous computerized banking possible. At a high level, the ATM is a computerized version of banking. In order to make sense of the ATM and to use it to bank requires mapping from both source domains into the blend. Working within the blend framework, bank customers may perform banking tasks using operations and formats from computing. The task representations are novel to banking but are easy to understand within a banking framework.

CHANGES IN TASK REPRESENTATION

Before Automated Teller Machines (ATM) existed, bank customers withdrew cash from bank accounts by physically entering a bank and interacting with a human teller (Figure 2). The activity resulted in the teller withdrawing money from or depositing some dollar amount into the customer's account. The entire activity was performed using teller-customer interaction, paper checks and slips, receipts, rubber stamps and so on. The human teller was the interface to the processes of interacting with a bank account.

Source 1: Banking
Task: Exchange money
Operator: Bank Customer
Representation: Analog
Interaction: Customer-teller
Structure: Spatial, Script

Source 2: Computing
Task: Create files, programs
Operator: Computer User
Representation: Digital
Interaction: Computer-User
Structure: Menu, command line, buttons keypad, keyboard

Blend: ATM
Task: Computerized money exchange
Operator: Bank Customer
Representation: Analog-Digital
Interaction: Customer-computer
Structure: Menu, buttons, keypad, script

Figure 2. ATM Blend Task Representation

Banking practice has created a powerful source domain by replacing concrete aspects of banking with symbolic ones. Statements, checks and signatures are all representations of concrete banking activity. The dollar amount printed on a statement is not stored in the bank with the customer's name on it, it's merely a representation of moneys in his account. Having one's money in the bank is not the same as having a stash of money in a mattress. The evolution to the symbolic representation of money has dominated banking practice and customers trust banks to hold money on their behalf. Bank customers have accepted and perpetuated the notion of conceptual banking by participating in this banking practice.

The ATM itself is a physical blend of the functional properties of a human teller and the computational properties of subtraction and addition. At ATMs a customer interacts with a text user interface, a set of buttons, and a bank card. On the ATM display screen customers are greeted by a welcoming statement in digital form, that says something like "*Welcome* to Bank of America's Versateller ATM, *Please* enter your card," and the transaction may end with a digital "*Thank you* for using Bank of America's Versateller ATM!" These kinds of greetings mimic a friendly human teller, and make the machine seem approachable and friendly.

When the customer enters his ATM card into the appropriate slot the digital interface prompts the customer to enter his personal identification number (PIN) and upon approval presents him with a set of options in a menu format. Each option corresponds to a button on the side of a visual display screen. The user indicates which option he prefers by pressing the corresponding button with his finger. The menu organizes the activity into a hierarchical and categorical format that adds a kind of structure and complexity to the task that did not exist before. The ATM blend is not a singular finite entity. It is an artifact and a set of actions that occur over time in the process of banking within a blended framework.

The ATM display screen also presents options for action that are, at first, presented as general categories of tasks such as withdrawal, deposit, view recent account activity, transfer money, and so on. Once the task is selected, the sub-level options are presented in a list format with options to specify the account (checking or savings) and the particular activity to be performed. Then, a data entry display is presented to specify a dollar amount. Cash is released through a small door and the display changes to ask the customer if he wants to perform other transactions. If he does, the top-level menu re-appears and if not, a receipt is printed and released through another small door and his bank card is returned from the slot where it was entered. Audio beeps are used to prompt the customer to remove his bank card, cash, or to enter an envelope for a deposit or payment. Transactions generally take less than a minute. The ATM blend presents banking tasks to a customer in a new format that combines banking and computing into a task format that did not exist outside of the blend.

Previously, banking offered customers a script for banking tasks. The spatial arrangement of banking slips, lines, and the row of tellers were spatial structure customers could use to build a script for banking transactions. The ATM mimics those same scripts by presenting the task in a menu format. The menu structures the task so customers may build expectations about the kinds of services that are available via the ATM and the kinds that are unavailable (such as applying for a loan) because unavailable services do not fit the teller script. The design works well in this environment because it is simple and does not unnecessarily complicate basic banking tasks.

There is some bank to bank variance in ATM display design, some have touch screens, others have labeled buttons. Menu formats may vary as well but the overall ATM conceptions are similar so if you use one kind of ATM you will likely be able to use another. In the San Diego region many ATMs offer a choice in display language between English and Spanish, reflecting the ethnic composition of the local communities. A language option would be more difficult to offer customers consistently with a human teller, but it is a feature that can easily be supported by the properties of the blend.

THE ROLE OF KNOWLEDGE

ATM displays are simple, organized, and limited. The transition from traditional teller banking to menu and button banking does not require much cognitive effort. One could stumble along pushing buttons and cycling through menus with general banking knowledge and general computing knowledge. However if one had no banking schemas, the displays would be difficult to understand because the task is presented within the larger conceptual framework of banking. By taking information about what the customer knows about banking and mapping that knowledge into a computerized device, customers can operate the ATM with relative ease, assuming they make the connections. However, people do make errors when using ATMs, they forget to take their card or don't remove the money before the door closes (Luchsinger, 1988). On occasion, I have observed ATM customers having difficulty canceling an unwanted operation and one gentleman I assisted did not understand the hierarchical menu structure.

Source: Banking	Source: Computing
Task: Deposit a check	Task: Input data
Operator: Customer	Operator: User
Structure: Spatial, script	Structure: Menu or Command-driven
Search: Visual	Search: Hierarchical, Categorical
Representations: Physical Check	Representations: Physical or Electronic
Data-Entry Tools: Pen, Deposit slip	Data-Entry Tools: Cursor, Mouse, Menu, Keyboard, Function Keys, Buttons

Blend: ATM
Task: Deposit a check, input data
User: Customer
Structure: Menu-driven
Search: Visual, Hierarchical, Categorical
Representations: Electronic, Physical check
Data Entry Tools: Customer's finger, Menu, Envelope, Keypad, Buttons

Figure 3. Operational changes to the task

Using an ATM itself is not a blend, but the task occurs within a conceptually blended framework. The end result of ATM banking is the same as traditional teller banking but the task performance is totally different. In figure 3 I present an elaboration of Figure 2, the blend's task representation, by showing operational changes the blend imposes on simple banking tasks. In the same way that task representation is blended, the operations used to perform the task are also blended. To deposit a check, a customer must visually search for the check and the bank card and then search through the menu options for the desired task and task options to make a deposit. The ATM version of a deposit is modified to include visual, hierarchical, and categorical search. The tools for accomplishing it are different and require the user make a leap from using traditional paper deposit slip and pen data-entry format to using a new digital data-entry format.

ATMs combine the functional properties of a human teller with the processing and networking capabilities of the computing domain. In the blend, the human interface is converted into a digital format that is familiar to computer users. The representations and the interactions are not specific to banking or to computing. The blending of task representation and task operation are a new dimension to conceptual blending that has not been revealed by linguistic examples.

CONCEPTUAL CHANGES IN BANKING

ATMs are changing the way we think about banking and the way we bank. The Automated Teller Machine is a recent artifact that offers access to one's bank account just about anywhere, anytime. ATMs appear outside most banks, on street corners, in small clusters, inside grocery stores, convenience stores, and shopping malls. ATMs are networked world wide, offering access to accounts from foreign countries that automatically compute foreign currency exchange rates. Ready access to ATMs has perpetuated the demand for convenient access to cash and accounts.

Source: Banking	Source: Computing
Task: Withdraw cash	Task: Print data file
Operator: Customer	Operator: User
Location: Bank	Location: Office, Home, Portable

Blend: ATM
Task: Withdraw cash
User: Customer
Location: Bank, Grocery Store, Convenience Store, ATM clusters, Zoo, Airport, etc.

Figure 4. New places to bank

ATMs have expanded our conceptual frames of various activities and locations to include banking as an additional service. ATMs appear in places banking activities has not been previously offered and created new conceptions of services available at various establishments. The schemas we may have held about the services of a particular business have been expanded to include banking and have created a conceptual shift in what it means to bank. This shift has created new conceptual blends that combine the services already offered by a business to include ATM services. Today, going to an ATM may be part of an entirely different activity from going to the bank (Figure 4).

The stand-alone feature of ATMs has changed how and where banking may occur, consequently the need to carry cash has diminished because ATMs are readily available and the conceptual models of accessing a bank account have changed. It makes sense to say: "I need to stop at a money machine" and "Is there an ATM in the park?" I recently saw a sign in a deli window that said "ATM available here" and banner outside of a liquor store that said "ATMs welcome here".

Social etiquette at an ATM was projected from the social practices of both banking and computing. Customers will wait patiently in line to use an ATM while standing at an appropriate distance from the person using the ATM. However it is not uncommon to see companions closely talking together while one uses the ATM and the other waits by his side. Similarly, computer users will huddle around a computer to cooperatively work together or look at a Web site. Most computer users offer privacy to another user entering his password into a computer account by looking away from the keyboard. At the ATM both behaviors are acceptable. The normative waiting patterns that are social practices at banks are recruited to structure the waiting patterns at ATMs everywhere. The fact that social rules of banking and computing are honored at the ATM is indicative of the conceptual power of the blend.

ATMs have given bank robbery new meaning. Banks have been "robbed" by thieves who took the ATM itself or broke into it. Individual customers have also been robbed while in the process of using an ATM. ATMs have expanded the notions of what it means to rob a bank and created opportunistic means of robbing.

CONCEPTUAL EXTENSIONS: THE CHECK CARD

Bank customers may receive two cards from their bank: the debit card and the check card. The debit card is specifically issued for use at ATMs and other debit-only services. At the ATM, the debit card functions as a deposit card, account transfer card, money withdrawal card. At gas stations and grocery stores one may purchase goods with a debit card. The check card also functions as a debit card, but it may be used wherever credit cards are accepted. For example, you may pay for your dinner at *Picasso's* with a check card, but not with a debit card, in the same way you might use a credit card to pay for dinner. The check card is a conceptual extension to the debit card and that extension is made possible by our understanding of debit cards, checkbooks, and credit cards. The check card carries structure from all three input sources. To understand how the check card works and the consequences of its use, one must draw upon knowledge from each of these domains. The functional characteristics of the card depend on context, where it is used and what is bought (Figure 5).

Source 1: ATM Debit Card
Operator: Account Holder
Representation: Plastic Card
Access: Checking/Savings Account
Location: ATM, Grocery, Gas station
Goods: Cash, Food, Gasoline

Source 2: Credit Card
Operator: Account Holder
Representation: Plastic Card, Emblem
Access: Credit Account
Location: ATM, Shopping mall, Restaurant, Phone purchases, Grocery, Gas, Retail stores
Goods: Cash advance, Clothing, Dinner, Tickets, etc.

Source 3: Check Book
Operator: Account Holder
Representation: Paper Checks
Access: Checking Account
Location: Shopping malls, Grocery, Retail stores
Goods: Food, Rent, Bills

Blend Extension: Check Card
Operator: Account Holder
Representation: Plastic Card, Visa Emblem
Access: Checking Account
Location: ATM, Shopping Mall, Restaurant, Grocery, Retail stores, Phone purchases
Goods: Cash, Dinner, Gasoline, Clothing, Food, Tickets, Grocery, etc.

Figure 5. The Check Card Blend Extension

The ATM debit card evolved into a check card. The check card is still an ATM card but it blends structure from three input sources: ATM debit card, checkbook, and credit card. The check card has the physical structure of a credit card, it is plastic, has account numbers, you have to sign the back of it, and it has a credit card emblem on the front, such as *Visa*. However, conceptually it is a checkbook, technologically limited to use where credit cards and debits are accepted, for example one cannot pay rent with a check card. In some cases the method of purchase blends the functions of a person with technology, a trend that has been extended to gas stations and grocery stores. There are gas stations where the presence of an attendant is no longer required because these cards and credit cards have eliminated that need. The checkers and station attendants are still a human interface to the purchase of goods, but it is conceivable that other service positions may be replaced with a kind of technology similar to the ATM.

CONCEPTUAL BLENDING PROMOTES DESIGN EVOLUTION

The construction of blended spaces is a key component of conceptual change in technology and evolutionary design. For example, the computer domain inherited its menu structure from general list structures in the restaurant domain. Menus on computer displays are commonplace structure in modern-day user interfaces. The computer in the machine is often transparent because these conventions seem natural.

The computer domain is quickly becoming a generic space for the design of new technological devices. As such, we should expect to see more artifacts that blend computer structure with other domains and we should see more conceptual blending in new technology. Artifacts such as beepers, cellular phones, and even hand-held global positioning systems devices all blend computing with other domains to create new artifacts with emergent task properties and representations. For example hand-held global positioning systems (GPS) blend navigation and computing.

The GPS device has structure from both source domains but it also has its own unique structure. The blend works because there is a shared system of relations that is preserved in the blend. Those relations are used to organize task representations and operations that are quite different from the representations and operations in either source domain and effect change in the way users think when they perform the task in the blended framework (Holder, 1995). For example pilots using a GPS must type their route into the device using an alphanumerical keypad or arrow keys instead of simply outlining the route on a sheet of paper. That pilots must type in a planned route introduces to the task possibilities for new kinds of error that were not present before. On the other hand, the GPS performs many computations automatically for pilots and can reduce errors pilots may have made performing those calculations. Still GPS introduces new complexity into navigation that was not present before and its use is facilitated by how the domains, navigation and computing, are exploited in the design.

CONCEPTUAL BLENDING FOR DESIGN ASSESSMENT

Conceptual blending analyses may be productive for identifying cognitive consequences of novel designs. Blending is a productive technique for unpacking a design and analyzing it to assess when it may or may not be appropriate to blend two or more domains into a new design. Decomposing the blend elucidates the convergence of conceptual and representational structure that has consequences for an artifact's use. The conceptual projections structure how the task or activity is conceptualized and consequently learned. These projections also constrain the range of possible uses that may be explored. When these mappings are ambiguous, we expect users to experience difficulty and when mappings are clear we expect the operations to be transparent. Task-level representations in the tool constrain how the task is perceived and those representations determine the kinds of operations that may be used and ways a task may be performed. It is at the task-level where we can use blending to predict and explain errors in user performance.

Fauconnier and Turner (1998), present a comprehensive review of conceptual blending and introduce a set of optimality principles unique to blends that impose competing constraints on blend construction. These principles serve as another dimension conceptual blending offers to design assessment. High quality blends conform to optimality principles that serve as design tradeoffs. The ATM blend conforms to integration, web, and context optimality principles.

The ATM blend is well integrated, it may be manipulated as an independent unit and so may its input sources making the conception and operation of stand-alone ATMs possible. Various banking activities give the ATM blend temporal structure that extends across contexts and conceptual task integration supports the same kinds of activities even though task implementation may vary.

The optimality principle of web emphasizes that connections between spaces be maintained without additional computations at a conceptual level. The integrity of the connections may vary according to task implementation, the ATM interface design, and the context. For example consider a deposit transaction, the bank customer is required to assume some of the teller's responsibilities. The customer must enter the deposit amount via a numerical keypad and also verify the correct amount was deposited. When operating within the blend, the bank customer simultaneously becomes a teller. Similarly at grocery stores the merchant becomes the teller, and at restaurants the waiter becomes the teller. In these contexts the actions of verification and exchange of goods are performed by someone else other than the bank customer, but conceptually the tasks are identical.

The power of the ATM blend lies in its versatility to support basic banking activities in a diverse variety of contexts. The integrity of the blend across contexts is due to the strength of the larger conceptual framework of banking. Even though task implementation may vary from location to location, customer's user their ATM cards in different contexts with little or no difficulty. And even though a customer may not think of buying gasoline with an ATM card as banking, it still works within the larger framework of exchanging money for goods. When we use the check card we are indeed banking, not charging even though the task implementation follows a charging script. When we pay for our groceries with a debit card and ask for cash back we are, in a sense, banking. Sometimes the implementation constrains the kinds of actions that may be performed but customers may utilize the context to map the banking activities available in a particular situation to the actions permitted by the type of bank card being used.

Banking itself is a conceptual activity so it is easy to exploit in blended space. A signature is a representation of an agreement, the account balance is a representation of available funds, but those funds are virtual they are not physically stored in a room labeled with a name. We have to trust the ATM in the same way we trust the teller for the blend to work. If the ATM eats your card or gives you the wrong dollar amount we have no recourse within the blended framework, we must step outside the blend and into the bank. That banking is already conceptual in its mechanics makes it easier to blend and manipulate with a symbolic domain such as computing.

CONCLUSION

The application of conceptual blending to design is a novel direction for the theory. In this paper I have analyzed the ATM to illustrate how blending might be applied in design analysis, especially in terms of understanding design elements. Blending analysis may be used to deconstruct a design, revealing the kinds of mappings that must be made, knowledge required to use it, task representations, and task operations. Once the mappings are made explicit, then they may be evaluated. Such an assessment includes understanding the underlying mapping structure, knowledge recruited, representations, and functioning. I introduced task-level representations and operations as new dimensions of blending. In addition to design assessment, blending may prove useful as a design guide and evaluative tool for assessing competing designs. User interface designers should experiment with using conceptual blending principles to make mappings explicit.

Conceptual blending theory is a promising tool that can be applied to understand the consequences of conceptual change in the development of new interface designs. The next step is to empirically test design blends for quality in terms of usability. Future work should investigate the possibility of blending principles that represent both desirable and objectionable features of design blends.

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REFERENCES

Baecker, R.M., Grudin, J., Buxton, W.A., and Greenberg, S. (1995) *Readings in Human-Computer Interaction: Toward the Year 2000*. 2nd Edition. Morgan Kaufmann Publishers Inc.

Cutrer, L. M. (1995) *Time and Tense in Narrative*. Technical Report 9501, Department of Cognitive Science, USCD.

Coulson, S. (1995) Analogic and Metaphoric Mapping in Blended Spaces. *Newsletter for the Center for Research in Language*, 9(1), 2-12.

Erickson, T. (1990) Working with Interface Metaphors. In Baecker, R.M., Grudin, J., Buxton, W.A., and Greenberg, S. (Eds.). *Readings in Human-Computer Interaction: Toward the Year 2000*. 2nd Edition. Morgan Kaufmann Publishers Inc.

Fauconnier, G. (1997) *Mappings in Thought and Language*, Cambridge University Press.

Fauconnier, G. & Turner, M. (1994). *Conceptual Projection and Middle Spaces.* Technical Report 9401, Department of Cognitive Science, USCD.

Fauconnier, G. & Turner, M. (1998). Conceptual Integration Networks. *Cognitive Science*, 22(2) 133-187.

Holder, B. (1995). *How to Fly to Catalina: Cognitive Aspects of Navigating with the Global Positioning System*. Unpublished manuscript. Department of Cognitive Science, University of California, San Diego.

Hutchins, E., Hollan, J., & Norman, D. (1986). Direct Manipulation Interfaces. In, D.A. Norman and S.W. Draper (Eds.) *User Centered System Design New Perspectives on Human-Computer Interaction.* (89-124). Hillsdale, NJ: Lawrence Erlbaum Associates.

Luchsinger, G. (1988). ATM Problems Nip at Banker's Heels. *Computers in Banking* Vol 5 (3), 12-16.

Mack, R.L. and Nielson, J. (1995). Usability Inspection Methods: Executive Summary. In Baecker, R.M., Grudin, J., Buxton, W.A., and Greenberg, S. (Eds.). *Readings in Human-Computer Interaction: Toward the Year 2000.* 2nd Edition. Morgan Kaufmann Publishers Inc.

Mandelblit, N. (1997). *Grammatical blending: Creative and schematic aspects in sentence processing and translation.* UCSD PhD. dissertation.