What Makes Square Dancing Hard?
Cognitive Psychology and Square Dancing

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There are limits to what the human mind can do. Studying those limits—and how people cope with them—can tell us much about what makes square dancing easy or hard: The closer a call or sequence comes to pushing those limits, the harder it is to perform. Looking at how people cope with their limits can tell us much about how people learn square dancing, and thus provide guidance for setting up teaching orders and plateau progressions.

Introduction

I started writing this in search of a way to decide what calls belong on each CALLERLAB plateau. There is some evidence [Neisser 67] that there are natural "plateaus" in the learning curve; it seemed to me that if we could take advantage of those natural stopping points, the CALLERLAB plateaus would be both more sensible and more stable. Unfortunately, it seems there is no way to predict where the natural learning plateaus lie, nor why they lie where they do. This lead me to try the more general question, what makes some dance routines harder than others?

Many things affect the difficulty of square dance material: Number of calls used, speed, body flow and smoothness, and the need for spatial orientation—among others. A lot of these are really only symptoms of one, more basic limit: the limits of what a human brain can do. By looking at what goes on inside a dancer's head, and at the limits he has to work within, we can get a good feel for what will be hard. I don't claim this approach can explain *all* of the difficulty in square dancing; it does, however, give us one way to measure difficulty.

Briefly, my claim is that the closer you approach human limits, the harder things get—and tasks which exceed those limits are impossible. Square dancing probes those limits in various ways: A dancer has only a very short time (less than 1 second) to hear a call and start executing it. This means he can't spend much time mulling things over—and there's a limit to how fast he can make decisions. There's a limit to how many things he can keep track of at once, so long, complicated calls are harder.

There is yet another factor: Each dancer has a sense of "rightness" about square dancing: He's constantly looking at what's happening and comparing it with his own set of standards for what is right. If he senses something wrong enough, he'll try to fix it. Any sequence which triggers this corrective reaction will be hard—the dancers will try to make mid-course corrections which are not needed, leaving them in the wrong place, leading to eventual breakdown.

Finally, there are different degrees of expertise in the various facets of dancing. Long-time dancers do things differently from beginners, and challenge dancers do things differently from Mainstream dancers. Looking at these differences can give us guidance on how to decide what call belongs where.

Dancing as Problem Solving

There have been some pointed remarks recently that dancing is becoming too much problem solving and too little enjoyment. While perhaps true, these remarks obscure a very important fact: *To some extent, every human activity involves problem solving.* Certainly, many of the problems are so simple you're not aware of them as "problems." Still, they get solved with the same tools we apply to hard problems—the difference is only one of degree.

Square dancing is one example of what psychologists call a "routine cognitive skill." [Card 80] That's a skill, like typing or playing ping-pong, which is well structured, but which involves continuous problem-solving behavior. If you're dancing relaxed Mainstream, the kinds of problems you're solving are the same kind you solve all the time in normal life—just walking and listening to the caller. It doesn't feel any different from usual. In fact, in relaxed dancing you're making *fewer* decisions than in normal life, so you feel more relaxed (the caller is doing all the thinking). That's what makes square dancing a good escape from the cares of the day.

But as the choreography gets harder, you start to have to think more, yet you're given no more time to react. That raises the level of tension, to a degree that some find unpleasant. With practice, though, C-1 dancers can be as relaxed at C-1 as Mainstream dancers are at Mainstream. They develop strategies for dealing with the increased complexity—and the complex dar.cing becomes much simpler! How do they do it?

People are lazy—they always try to make things simpler. Every time you face a problem, you try to solve it the simplest way you can. If you see a particular problem often, simplifying it can pay off handsomely—so when you practice some skill, you are unconsciously using several strategies to make your job simpler. The reason a problem is hard at first is that it's either too big to "see" all at once ("memory load"), or it takes too many decisions to solve it in the time you have ("decision load"). The strategies you bring to bear on a problem are aimed at reducing these loads.

To understand this, let's look first at what happens while you're dancing. Then we'll look at the limits you operate within, to get a feel for what makes hard dancing hard. Finally, we'll look at how people make hard dancing easier for themselves—which will tell us a lot about how dancers should be taught, and how the level plateaus should be structured.

What Happens as You Dance

Let's look at what happens while you are dancing:

- The caller says something
- You hear it, and recognize it as a call
- You figure out what you're supposed to do, and
- You do it.

Actually, each of those steps is made up of a complicated series of substeps:

As the caller speaks, the sound hits your ear. Between ear and brain, there is a short memory, called the "echoic memory." This memory will hold sounds for about 1½ seconds, giving your brain some time to work on them. Anything which isn't handled in those 1| seconds will be lost.

You are always listening to things around you, and your brain is taking sounds from the echoic memory and trying to make sense of them. This is what happens when you listen to someone speaking. As you listen, you are grouping sounds into words, and words into phrases. You do that from your built-in sense of how English is put together—the vocabulary and grammar you learned in early childhood.

In the same way, every dancer has a built-in sense for how the caller puts words together to make calls, and how calls go together to make sequences. As words come in, they are fitted into that structure, and grouped into whole call names, phrases and so on. Furthermore, there is a "grammar" for square dance calls, much as there is for English. Dancers know that grammar unconsciously, and it guides how they interpret what they hear. Phrases which are "ungramatical" cause the dancer to try to make a correction—to figure out "what he really meant."

For example, the sequence "TURN AND DEAL, AND ROLL LEFT TO A WAVE" can be confusing. Hearing it, a dancer may well group "TURN AND DEAL AND ROLL" together. Then the other words won't make any sense, and he has to go back and try again.

Now that you've heard the call, how do you figure out what to do? People use a number of strategies. Being lazy, they always opt for the simplest that will work. The simplest is to always do the exact same thing for a given call: "He said FAN THE TOP, so I step forward and use my left hand." This is a simple stimulus-response behavior, with the response being actual body motions; it isn't very flexible, and leads you astray if you're anywhere even the least unusual. The next simplest is to respond with a fixed path to follow: "He said ALL EIGHT CIRCULATE, so I'm going to end up *there*." That's still straight stimulus-response, and it buys you the flexibility to do a call from a few more places, but it's still too limited. Finally, you can actually use the definition: "He said FAN THE TOP, and I'm the end of a wave, so I move forward and to the right around a ¼ circle." Skilled dancers use a mixture of these strategies, even for a single call: Most people

can do FAN THE TOP from normal couples in their sleep—but do it from sashayed couples, and they have to back up and think.

Those strategies worked fine for well-learned calls, but what about something unusual? Now you have to apply the definition to the new situation; this may involve "replaying" the call's definition to yourself, so you can pick out the right part. "He said SWAP AROUND. That's a Belles walk ahead while Beaus flip over. I'm the belle here..." All of this figuring takes time.

Now that you know what to do, what goes into doing the call? This depends on what you decided was the "right thing to do." You can execute simple or well-practiced calls without further thinking—what you recall is a series of motor actions. Otherwise, you'll be spending some effort in the execution: If you're doing an unusual part, or if the call is a new one, you'll be silently chanting out the parts of the call as you do them; Some calls (like CIRCULATE) demand that you end up on a specific spot on the floor; if so, you have to find that spot and and remember it while you're getting there; Other calls (*e.g.*, CHAIN REACTION) move differently from different starting formations, and you may have to decide in mid-execution which path to take; Finally, many calls end with dancers making some specific formation (RELAY THE DEUCEY, where you have to "move up to form waves"), and you have to make sure you've moved up to the right place.

As you can see, there's a lot going on. So much, in fact, that if you had to think about it all you'd be swamped. So you unconsciously simplify, simplify, simplify!

The Limits of Human Performance

There are limits to how quickly humans can do things, and how much they can do. Square dancing probes those limits in various ways; the closer a call (or sequence of calls) comes to pushing the limit, the harder it is. What are the limits? There is a limit to how fast you can decide something (about ¼ second per decision); there is a limit to how much you an keep track of at once (5–7 things); there is a limit to how much time you have to react to a call and start moving (about 1 second).

A problem can usually be solved several ways. This lets people cope with their limits by trading one thing for another. The trade-offs that dancers make will be shown below.

Memory Limits

Every action a person takes is under the control of his short-term memory (STM) [Klatzky 75, Card 83]. That's where he keeps track of what he's doing, what the next step is, what to watch out for, and so on. It's also where he keeps interim information while working on a problem. A person can only keep 5–7 things (called "chunks") in his short-term memory at once

[Miller 56]. In square dancing, some of these are occupied with holding a call's definition, some with actually dancing the call, and some with listening to the next call. The more short-term memory a call requires, the harder it is. In fact, with some thinking, you can load up a call with if's and's and but's to the point where it takes so much to keep track of *what the call is* that there's no room for remembering *how to do it.*

New dancers are especially subject to frequent memory overloads (and thence fumbling). They're still at the stage where each individual step or hand movement needs to be remembered. With repetition, though, they begin to group actions together into chunks. For example, let's look at the call RIGHT AND LEFT THRU. For experienced dancers, the call—well, it's just there. But for a man who is just learning the call, it's a lot to remember:

- Find the lady I'm facing
- Take her right hand in mine.
- Walk past her, remembering to exert some pull on the hand-hold.
- Remember to drop the hand as we pass each other.
- Stop walking forward.
- Find my partner.
- Reach out and take her left hand in mine—but don't turn my body while I do it.
- Put my right hand in the small of her back.
- Start to back up, while she walks forward.
- Remember where to stop turning.
- Let go of her left hand.
- Take my right hand from her back, and take her left hand with it.

The places you see a newcomer fumbling in this call are the places where he runs out of memory: The step "Find my partner" is probably still hard (he hasn't practiced it much), so he may forget to stop moving forward while he does it; It's natural to turn while reaching for your partner's left hand, so he has to actively remember not to—and often forgets; While doing the COURTESY TURN, he's walking backward, which is unusual and takes some concentration. He's also spending a lot of effort making sure to stop on time, and may forget the hand motions that follow.

With practice, though, he becomes less aware of each individual motion. The call resolves itself into fewer and fewer parts, until finally he is only aware of hearing the call and doing it. This frees most of his short-term memory for other things. This process of combining small movements into a single larger call is one example of a process called "chunking:" several chunks are combined to make a single chunk. The dancer now thinks of the call as one thing, and it only takes one chunk of short-term memory.

Chunking occurs everywhere: As you hear the four words "Right—and—left—thru," you group them into a single chunk, because they make up a single *idea.* When you think of a squared-up set, you don't think about each of the eight dancers, or even each of the four couples. You get a picture of the whole square at once—again, it's a single idea.

The thing that drives the chunking process is repetition. If you always experience certain things together, your start to compress them into a single, composite experience, and to think of the experience as a whole rather than as its parts. Chunking also seems to happen in "layers:" First you chunk the very smallest things together. Then you start to chunk the chunks. Then the chunks of chunks, and so on. Each round of chunking takes about the same amount of practice—the same number of repetitions of a call, for instance.

As calls get longer and more complicated, you also have to keep track of where you are within the definition. This takes at least one chunk of STM, and adds to the memory load for long calls. You most often need this where the call has a lot of similar parts, *e.g.*, RELAY THE DEUCEY with all those arm turns. Unless you keep track, it's easy to lose your place and try to go too far.

Finally, you are using some of your STM in listening for the next call. If the caller starts speaking too early—while you're still using all your STM on the call you're doing—something gets lost.

Decision Making

A human can make about 5 decisions a second. Not conscious decisions, but all the little checks and look-outs that have to be made to do anything. In square dancing, some of them go to figuring out what the caller is saying, some to figuring out how to do the call, and some to actually doing the call. The more decisions you have to make in a given time, the harder it gets. And if you have to make too many decisions, you fall behind.

Let's look at a sequence of calls, starting from a static square: Heads SQUARE THRU—CURLIQUE—FAN THE TOP. What goes on just after you hear that last call? You decide you're not in facing couples, so you're in a wave. Now—are you an end or a center? Which way do you head? Which part do you do? Bang! You've fallen behind.

Humans cope with the limit on their processing ability in 3 ways: By anticipating, by trading processing for memory, and by using clues from their 5 senses.

As you listen to the caller, you can often tell what the next few words have to be. That's because square dancing has a fairly strict grammar: At Mainstream, if you're in a wave and the caller has said "Fan," you can be pretty certain that the next two words are "the Top." Once you've come to that conclusion, you can start to work on doing the call—giving yourself an extra half

second or so. In normal conversation, people seem to predict 2 or 3 words ahead—and can often complete the speaker's sentence for him! This same anticipation happens as dancers listen to the caller.

If a dancer hears a particular sequence of calls enough times (say HALF TAG—TRADE—ROLL), he unconsciously starts to assume that they're part of the grammar of square dancing—that they'll always come in that order. This is popularly called "anticipating the caller." Once he's heard the "HALF TAG," he'll anticipate the rest. This is quite common: How many dancers can do HALF TAG—TRADE—SCOOT BACK? Darn few. They all do the TRADE AND ROLL, regardless of what the caller says. That's because the dancers have come to consider the three calls to be inseparable. That particular sequence of calls has been become part of their grammar for square dancing.

The first few times you hear a call, you spend time figuring out what to do. Once you've heard it enough, you start to recall the right actions, rather than figuring them out—the processing load has been changed into a retrieval from long-term memory (LTM). This can have some bad side-effects, though: If a dancer always sees a call from the same place, he only learns the one part. If you call it from somewhere else, he'll retrieve his normal part and start moving before he realizes that's the wrong thing to do. Watch the men trying to do Fan the Top from half-sashayed facing couples, or watch the side man if you have HEADS PASS THE SEA—CHAIN REACTION: He's so used to moving forward that he'll do it even when there's no place for him to go.

Experienced dancers learn to associate ending formations with calls, so they no longer have to grope for the wave when the caller calls "CURLIQUE—FAN THE TOP." Here, the processing has been traded for a retrieval from LTM, and a chunk of STM. For an APD dancer, this trade-off is quite beneficial, so it becomes habitual quickly.

Finally, people use clues from their five senses to help them. More experienced dancers always join hands whenever possible; this gives them a tactile clue to help in finding the formation. Then there's a clue which almost every dancer uses without knowing it: body flow. By and large, square dancing doesn't change a dancer's body flow—if he was moving forward at the end of the last call, he'll probably start the next call by continuing to move forward. Therefore, people tend to stay in motion, even when they're not finished figuring out what to do. This buys another bit of time to think. It also means that a caller can use body flow to defeat the dancers: Look at PASS TO THE CENTER—CENTERS PARTNER TRADE. The centers' forward body flow takes them into a STAR THRU with each other before they can stop it.

Time

On top of all else, it takes time to recall thing from LTM. The less often you've heard a call, the longer it takes—practice has a strong effect on retrieval time [Newell 81]. Interference also affects recall time: If there are two calls which sound alike, it takes time to decide between them. And if there are two calls whose definitions are similar, you'll also have to decide between them—which takes time as well.

Critics and "Patching"

Everyone has a sense of rightness about the world. Likewise, dancers have a sense of rightness about dancing. If they hear, see, or feel things which violate that sense, they'll try to fix them. This is a way for keeping small mistakes from growing into big ones. "A stitch in time saves nine."

You can think of each dancer having a chorus of subconscious "critics" always on the lookout. If a critic sees something he doesn't like, he raises a warning; if the warning gets loud enough, the dancer will so some small thing to make it feel righter. This correction process is called "patching," from the idea of patching a tire.

I have identified three kinds of critics:

- Positional: Your position relative to other dancers feels wrong: Dancers who are left facing out for a long time tend to turn around; Half-sashayed couples tend to fix themselves; Left-hand waves tend to become right-hand waves. This is why SLIDE THRU from same sex facing is so hard—everyone is *sure* it ends in a couple.

- Flow: If it feels unfamiliar, it feels uncomfortable, which feels wrong. COURTESY TURNS with the lady backing up are one example. Another is the entire class of left-hand versions of the calls SPIN CHAIN THRU, SPIN CHAIN THE GEARS, etc.

- Call pre-requisites: If you're expecting to do an ARM TURN with someone (even though the call's definition says you "TRADE"), and that person is facing the same way you are, you think somebody's wrong.

What does this mean? Think of it this way: Each dancer has a discomfort level. When everything feels OK, the discomfort level is low. If he hears unusual calls from odd places, his discomfort grows. If, on top of that, his critics start to clammer, he'll try to patch—even if everything was perfectly allright! The lesson is this: to get people through unfamiliar material, keep their critics silent. If the formation is odd, make the flow familiar, if you have people in odd places, make reassuring noises...

Dealing with modifiers

The next feature that dancers face is the need to apply some modification to they way they do a call. The Advanced "As Couples" concept is a simple one, and is followed closely by the C-1 "In Tandem" concept. These both require the dancer to treat a group of dancers as a single entity for the purpose of doing the call. This in turn requires you to do the call differently: You have to remember each part of the call in order, then do that part—suitably modified. No longer will simple stimulus-response dancing work. These aren't too hard *a priori*; their difficulty derives from the new way you have to think of calls.

The next class of modifiers requires the dancer to find the other dancers he is working with, and to know where he's going. The C-1 Blocks and C-2 Once Removed concepts are common examples. They involve the skill of re-casting a group of dancers as though they were in a single, tight formation, doing the call, and going to the correct original spots. In addition to the new way of thinking about calls, these are hard because of the added STM load for remembering the spots on the floor.

There is a tougher version, where dancers must visualize with non-existant phantom dancers. This is harder yet than visualizing with real people, because you don't even have clues for where the spots are. And with eight real dancers and eight phantoms, you're awash in places to remember.

Degrees of expert behavior, or How do people execute calls?

There are real differences between novice and expert behavior in square dancing. The main differences come in four areas: Figuring out what to do, how you do the call, sophistication of critics, and better use of environmental clues.

What to Do

There are several levels of expertise in recalling what to do for a call. The least experienced dancers—or dancers who have danced only "standard" positions—think only of the call's name. A beginner lady, hearing "Wheel Around," will start to walk forward and to the left, even if she is the beau; many a man, hearing "Fan the Top" from facing couples, will walk forward and to the right, even if he's the belle.

The next level is to use the call and your position—but not to think about the whole formation you're in. This takes care of the Wheel Around and Fan the Top problems, and serves pretty well in most other situations. Dancers at this degree of sophistication tend to think of, say, waves, without thinking of whether they're right- or left-handed. Thus, a lady beginning advanced dancer who is on the outside for a Chain Reaction will decide what to do based on whether she is a beau or a belle. But if the wave in the center is left-handed, the parts are reversed—leading her to do the wrong part. The top level, then, is to consider the call, your position, and the entire formation when deciding what your part is.

How Do They Do it?

Once you've figured out what to do, what gets retrieved from your memory? Again, the answer is different for dancers of differing expertise. A beginning dancer retrieves rote motor actions for his body to perform, and performs them. This works well when dancers are close together and there are lots of opportunities for touching other dancers and making minor course corrections—for calls like Ladies Chain, Right and Left Thru, and the like. For calls like Circulate, though, it starts to break down.

Circulate is different—you sometimes have to go quite a ways to your final spot, and still get there accurately. You also aren't touching anyone on the way there, so you have no places to make mid-course corrections. If you are the end of a wave facing out, you have the hardest part. The only way to get there consistently is to think of the spot you're going to, then go there. This is the next level of expertise in call execution, which I call the "target" method: Pick a target spot before moving, then go there. This becomes vital when you are dancing calls where everyone is working alone, and everyone is moving. Without that target in mind, it is very easy to get lost. This is one reason that dancers are taught to point where they're going for calls like Trade the Wave and Trade Circulate.

Neither of the above methods will help you to do "As Couples" moves. That—and many other concepts at the Advanced and Challenge plateaus—require yet a third recall technique: You have to recall each part of the call, and be able to interpret that part in the right context. For As Couples Swing Thru, the "1/2 by the Right" has to be done by a pair of couples. For In Your Block Walk and Dodge, the leaders have to Dodge to the adjacent spot in the block. To do one of these calls, you have to be able to replay the definition and do the modified action. Truly expert dancers don't recall the words of the definition, they recall chunks of the definition—the "1/2 by the Right" is a single thought rather than several words.

Critics

Not surprisingly, an expert dancer's critics are more sophisticated than a beginner's. Their improved knowledge of where things end makes the critics more reliable, and less prone to false alarms. Body flow is less a factor (though uncomfortable flow is still a clue). Improved positional critics, language critics, Ability to patch in words which are missing or change calls to the closest one which fits... All are part of the expert's arsenal.

Shedding Load

Finally, expert dancers are very good at shedding load:

- **Making better use of environmental clues:** Experts join hands whenever possible, which keeps formations from breaking apart in confusion when the going gets rough. They point at their ending spots before moving, thus providing reinforcement for the Target method.

- **Moving memory burdens to those who can handle it:** Experts informally assign responsibility for remembering things to the people who are in the best place to do the remembering. Things like where to stop on RELAY THE DEUCEY.

- **Minimizing the STM load of harder concepts:** There are mnemonic devices for remembering where people belong (*e.g.*, finding the diagonal of a BLOCK formation that is made of real people).

- **Throwing away things they don't need to remember:** In the more involved phantom calls, the call is always phrased so the dancers can figure out which spots on the floor are relevant before they hear the actual call. Experts, therefore, restrict their attention to the fewest possible phantom spots—and no longer have to remember where the others are, so there's more memory available for doing the call.

A Difficulty Measure

Now it's time to build a composite measure of difficulty. The measure is a list of hard points. The more hard points a sequence has, the harder it is.

- The less often a dancer sees a call at all, the harder it is (PEEL OFF, for example).

- The less often a dancer sees a call from a given formation, the harder it is. Say PEEL OFF from waves.

- The less often a dancer sees a call from a given position, the harder it is. Say FAN THE TOP from sashayed couples—the ladies try to LEFT ARM TURN ¾ with each other, while the men move forward and to the right.

- The more chunks of STM a call takes to execute, the harder it is. RELAY THE DEUCEY is a good example of this. So is TEACUP CHAIN. To carry it further, a call whose name takes many chunks of STM may be impossible!

- A call where pre-existing body flow tells you nothing is harder than a call where pre-existing body flow leads you right.

- A call where pre-existing body flow leads you astray is harder still.

- The more places a call has where you have to decide what to do next, the harder it is. CHAIN REACTION from odd formations is this way, as is RELAY THE DEUCEY before you've learned it thoroughly.

- A call which causes a dancer to anticipate incorrectly is hard (*e.g.*, HALF TAG—TRADE—SCOOT BACK)

- Putting a dancer in a place where he will try to patch makes it hard: Dancers left facing out for a long time will turn around; inexperienced dancers will try to change from half-sashayed couples into normal couples.

- Calling a call which the dancer will try to patch makes it hard (from a static square, HEADS SPIN THE TOP often gets done as a FAN THE TOP, because the dancers don't believe the caller meant it).

- A call which takes more than 1½ seconds for the caller to say will be hard, because dancers won't be able to hear the whole call as a single unit—they'll have to hold onto pieces of the call until they've heard the whole thing.

- On the other hand, the call may contain a part that the dancers have to parse a bit at a time, like "PHANTOM SPLIT LINES INTERLOCKED PARALLELOGRAM [*whatever*]". If so, it is much harder to handle if the caller doesn't pause between the parts of the name.

- The more similar a call is to another call (in name or in action), the harder they are to keep straight.

- A call which requires chunk-stream recall-and-modification is harder than a regular call. Any AS COUPLES call that you haven't seen before feels like this.

Conclusions

What can we conclude about difficulty? That human cognitive limits are the source of much dancer difficulty. A decent respect for dancer success dictates that callers play to those limits, rather than using them as a way of increasing difficulty. This will affect the caller's choice of word order, body flow pattern, and positioning. Recognize the existance of a "grammar" for calls, and use it rather than fighting it. In particular, make it easy to figure out what you meant, rather than requiring the dancers to be legal eagles. Calls which flow together well are easier, regardless of the "true" difficulty of the sequence; by the same token, poorly-flowing calls are harder. Finally, one must for dancers' sense of rightness, so they don't wind up scrambling to correct needlessly.

What can we conclude about the ordering of calls on the lists? Because of people's chunking mechanism, they'll do best if the teacher builds a vocabulary and

uses it often in defining new moves. Because of acoustic and semantic interference, calls which sound alike or whose definitions can be confused should be widely separated in the teaching order.

What can we conclude about teaching practices? Build the dancers' vocabulary. Recognize the tendency to over-simplify, and provide enough unusual material to keep dancers doing the whole definition: It isn't enough to teach the whole definition—it has to be practiced regularly. Help the dancers build good critics by giving them exposure to the less common—but still perfectly legitimate—positions and usage.

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