David Alciatore, PhD ("Dr. Dave") **ILLUSTRATED PRINCIPLES**

"Squirt – Part III: follow/draw squirt and swerve"

__Note__: Supporting narrated video (NV) demonstrations, high-speed video (HSV) clips, and technical proofs (TP) can be accessed and viewed online at __billiards.colostate.edu__. The reference numbers used in the article help you locate the resources on the website. If you have a slow or inconvenient Internet connection, you might want to view the resources from a CD-ROM or DVD. See the website for details.

This is the third article in a series dealing with "squirt." So far, we have looked at basic terminology, the physics behind squirt, and some experimental results. To refresh your memory, **squirt**, also called **deflection**, refers to the angular change in the initial cue ball (CB) direction due to an off-center hit. In other words, when you use English, the CB doesn't go where you are aiming because of squirt. For more background information, see my August '07 article and refer to **NV 4.13** and **NV A.17**. When using English, it is also important to be aware of the effects of **swerve** (see **NV 4.14** and **NV 7.12**) and **throw** (see **NV 4.15**, **NV 4.16**, **NV A.21**, and my August '06 through July '07 articles). Sometimes, the term "**effective squirt**" is used to refer to the net effect of both squirt and swerve on the shift in the CB position at object ball (OB) impact (see my August '07 article for more information). If you want to refer back to any of my past articles, they are all available on my website (__billiards.colostate.edu__).


normal video

NV 4.13 – Squirt due to high speed English
NV 4.14 – English curve due to an elevated cue
NV 4.15 – Using throw to make a partially blocked shot
NV 4.16 – Over-cutting a cut shot to compensate for throw
NV 7.12 – Small-curve massé shot
NV A.17 – Effective squirt vs. speed
NV A.21 – Bank shot using throw and spin transfer

This month, we'll look at the effects of follow and draw on squirt, swerve, and effective squirt. **Diagram 1** illustrates how swerve and effective squirt differ for follow and draw shots. With a draw shot, the CB slides along the cloth longer before the CB begins to roll in a straight line. With a follow shot, the ball stops sliding and begins to roll much sooner. Because swerve occurs only while the ball is sliding, a draw shot persists longer along the initial squirt line, and the swerve happens more gradually. The end result is: a follow shot will have less effective squirt than a draw shot of the same amount of tip offset. For more details and a further explanation on this, see page 7 of **TP A.19**.


technical proof

TP A.19 – Masse shot aiming method, and curved cue ball paths

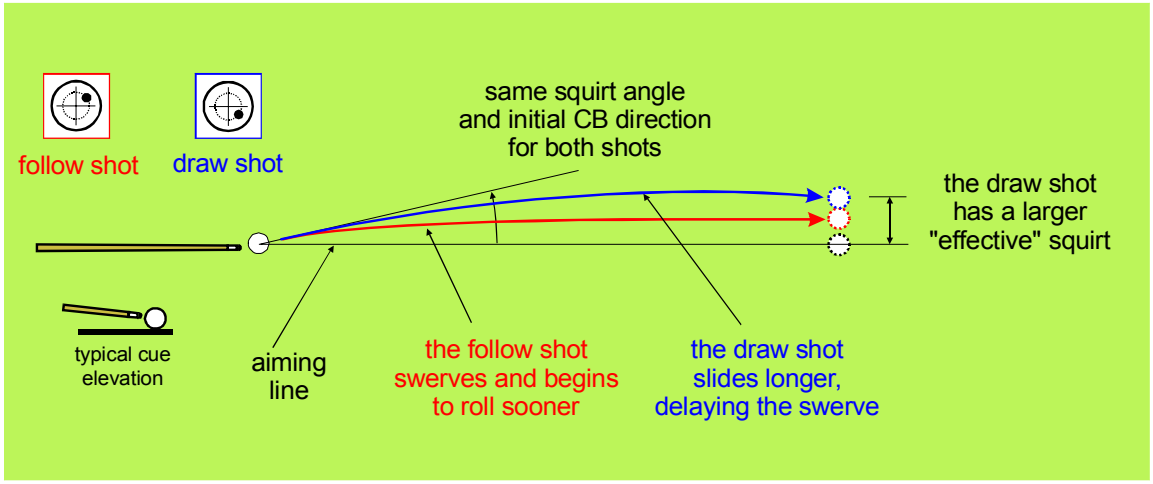

Diagram 1 Squirt and "effective squirt" for draw and follow shots

Recently, I ran a few experiments to verify all of the claims in Diagram 1. When I first performed squirt experiments with draw and follow shots (see last month's article for a description of the experimental setup and procedures), I was getting different squirt results for follow and draw shots. In one experiment, I was getting average draw squirt values of 2.4° and average follow squirt values of 1.9°, using the same tip offset and speed for both shots. However, this was before I discovered the effectiveness of Silicone spray. After Bob Jewett and I had a conversation about all of the possible reasons for differences in squirt between draw and follow shots, we came up with the idea to redo the experiments, with the CB and plastic surface (over the table cloth) sprayed with Silicone spray. This practically eliminates swerve as a factor, especially over the relatively short distance of my experiment's measurement. With swerve out of the picture, I measured identical average values (2.5°) for squirt for both the draw and follow shots. So the squirt angle is the same for both draw and follow shots; but as shown in Diagram 1, the effective squirt (after swerve comes into play) can be much larger for draw shots vs. follow shots.

Diagram 2 shows what would happen if the CB were struck with a perfectly level cue, or if there were no friction between the ball and the cloth. In either of these cases, swerve would not be a factor at all, and the CB would head perfectly straight in the initial squirt direction. Unfortunately, neither of these situations is realistic at a pool table. The cue stick is always elevated some because the back of the cue needs to clear over the rails, and even if the cue was not over a rail, your grip hand would need some clearance above the table. You can contrive shots where you can create a level cue, but these shots would not be very practical in a typical game of pool. Having said all of that, it is useful to know to keep the cue stick as level as possible to limit the amount of swerve of a shot. The ball and cloth conditions also affect swerve. With a new, clean, smooth, and polished CB on a very slick cloth, the swerve will be delayed and the CB will head along the initial squirt line longer before curving, and the curving will take place more gradually. In my experiments, I was able to simulate the super slick conditions with the Silicone spray, mostly eliminating swerve as a factor. The result was equal squirt angles and straight-line CB motion (over a short distance) for follow, draw, and stun shots (of equal horizontal tip offset). A final factor that can limit swerve is shot speed. As implied in Diagram 2, if faster speed is used, swerve won't be much of an effect (especially over shorter distances), as compared to squirt.

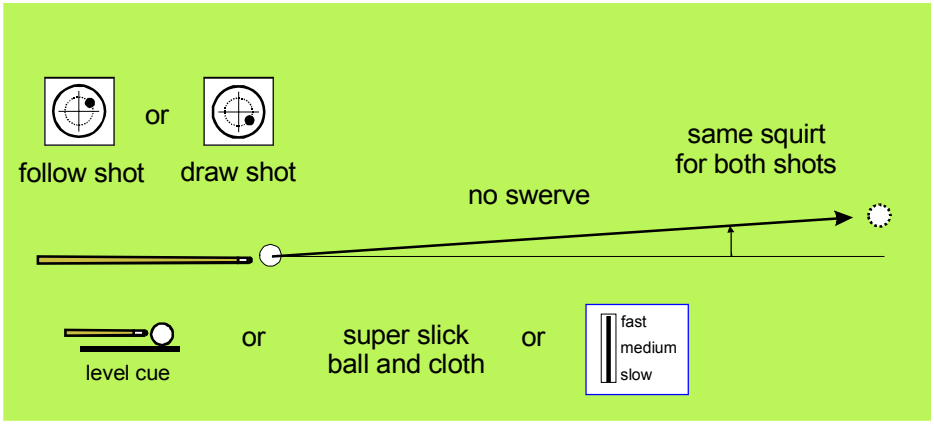

Diagram 2 Swerve-free squirt

Diagram 3 shows the effects of speed and cue stick elevation on swerve. In shot "A," the cue is elevated the typical amount (not very much), and fast speed is used. Here, the squirt dominates, and the swerve reduces the effective squirt but doesn't bring the CB back to the original aiming line. In Shot "B," the cue stick is elevated a little more than normal, and a slower speed is used. In this case, the swerve exactly cancels the squirt (for a certain shot distance). The final CB position is exactly on the aiming line (i.e., the CB went exactly where the shooter was aiming, which is very unusual when English is used). For a given shot distance and for a given amount of English and for a given cue stick, there are always certain combinations of speeds and cue stick elevations that will result in zero effective squirt, but all of this is difficult to judge reliably. We'll talk more about aim-compensation techniques in a future article.

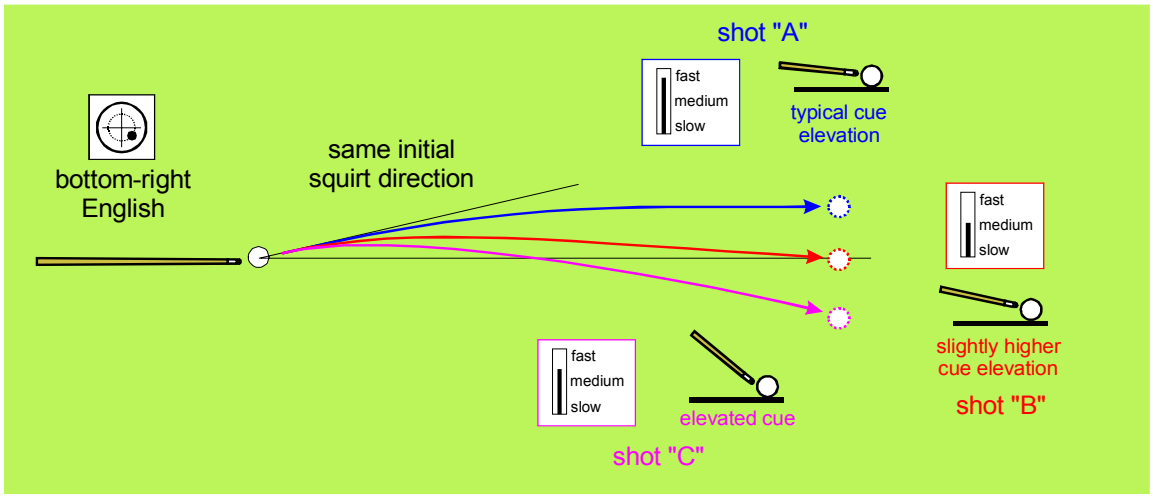

Diagram 3 The effects of speed and cue elevation on swerve

Some people claim that squirt is not a factor in their game. Well, if you don't use English much, that might be true. Or if you have years of successful experience and have reliable and subconscious intuition for automatically compensating your aim, maybe you never need to think about squirt and swerve. Another possible explanation (although, also unlikely) is that you are good at using cue elevation and speed to have squirt and swerve cancel on shots where you use English. Whatever you think, if you don't appropriately compensate for squirt and swerve

(consciously or subconsciously), you will miss some shots, even if you are using a low-squirt cue (to minimize squirt) and near-level cue elevation (to minimize swerve).

Shot "C" in Diagram 3 is called a massé shot, because the cue stick is elevated much higher than normal and the swerve effect dominates (e.g., see **NV 7.11**). Here, the CB curves well past the original aiming line, opposite from the squirt direction. If you want to learn more about masse shot aiming and speed effects, see my November '05 article.


normal video

NV 7.11 –- Large curve massé shot

I hope you are enjoying and learning from my series on squirt. Next month, we'll look at back-hand English, front-hand English, and pivot-point calibration. I hope you look forward to the remainder of the series.

Good luck with your game,
Dr. Dave

PS: If you are interested in the math and physics behind squirt, you might want to check out an analysis I recently posted on my website (see **TP A.31**).


technical proof

TP A.31 – The physics of squirt

PS: I know other authors and I tend to use a lot of terminology (e.g., squirt, throw, cling, stun, tangent line, 30º rule, etc.), and I know not all readers are totally familiar with these terms. If you ever come across a word or phrase you don't fully understand, please refer to the glossary in my book. For convenience, an expanded electronic copy is posted online in the "Instructor and Student Resources" section of my website.

PS: I just released a new DVD called "High-speed Video Magic." It features billiards, but it also includes stupid human and animal tricks, balloons popping and bouncing, things breaking, engineering stuff, toy physics, and fluids and foods in motion. For more information and video excerpts, see the website (*billiards.colostate.edu*).

Dr. Dave is a mechanical engineering professor at Colorado State University in Fort Collins, CO. He is also author of the book, DVD, and CD-ROM: "The Illustrated Principles of Pool and Billiards," and the DVD: "High-speed Video Magic."