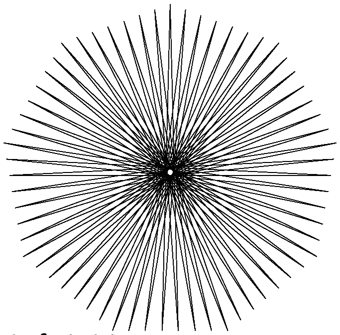
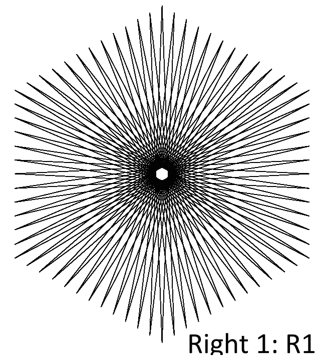
1.1.1. A Comparative Introduction, Part I



Left 1: L1

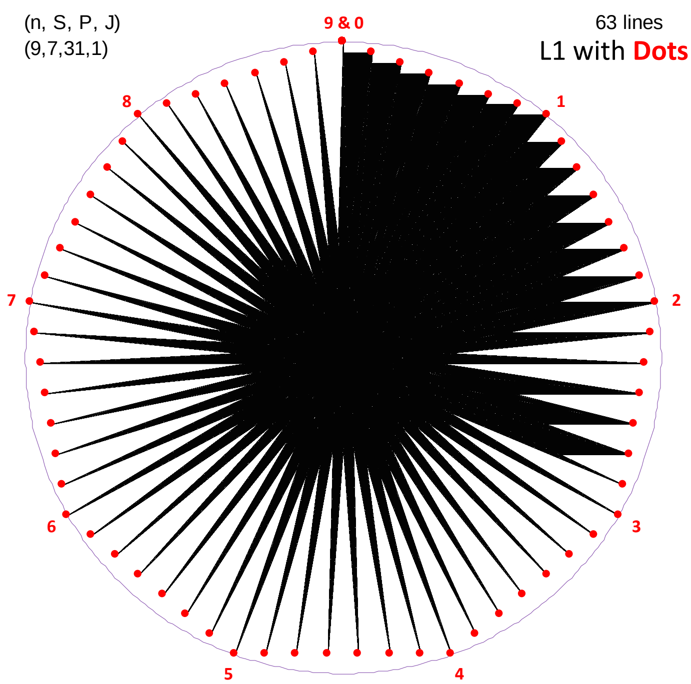
String art is a well-known activity (480 million results in a *Google* search) that uses string, a board, and nails to produce artistic images. There are variations that use different modalities such as needle, thread, and art board which produce images like the ones shown to the left and right. The intricate internal forms are created by stretching the thread from side to side and not by placing holes in the interior of the image. This activity is beloved because simple counting rules are used to create beautiful images that can both adorn walls and excite young minds.

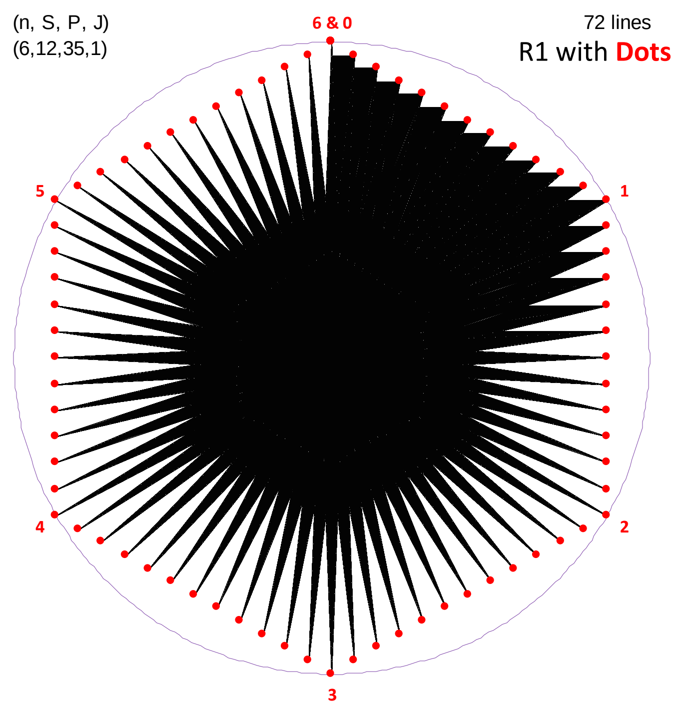


Right 1: R1

Traditional versus electronic. The downside of the traditional highly tactile activity is that it can be quite time-consuming and inflexible. It takes time to set up the board, pound in the nails, and create an image using string and a specific counting rule (such as "connect every 31st nail"). Traditional string art can also lead to frustration if you want to modify the image. It is challenging to change nail placement once the nails are secured to the board and changing the counting rule requires removing the prior image from the board. By contrast, electronic string art offers much more flexibility to change "nail locations" and counting rules. In an electronic setting, these adjustments are accomplished easily by changing parameters. By altering three parameters – the number of vertices (***n***), the number of subdivisions (***S***), and the number of subdivision endpoints between drawn lines (***P***) – users can turn the image on the left above into the one on the right in a matter of seconds.

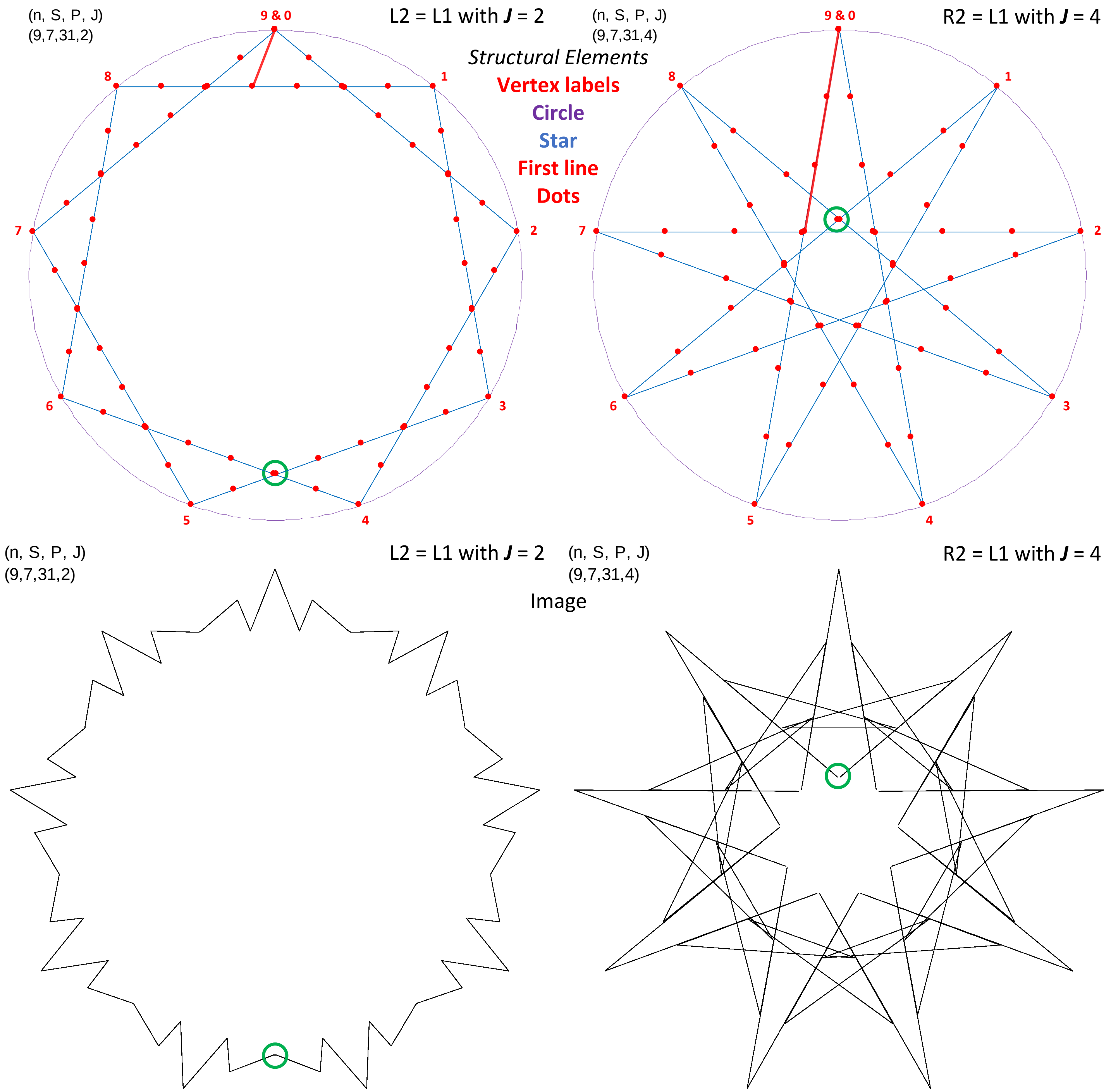
Moving from the left to the right image above requires changing ***n*** from 9 to 6, ***S*** from 7 to 12, and ***P*** from 31 to 35. The **red dots** below are "subdivision endpoint nail locations" for both images. L1 (Left 1) has 9 vertices (and sides) and 7 **dots** per side (9·7 = **63 nails**) with a line connecting every 31st nail. R1 has 6 vertices and 12 **dots** per side (6·12 = **72 nails**) with a line connecting every 35th nail. The counting rule ***P*** in both images was to count *almost* half-way around the set of **63 dots** on the left and **72 dots** on the right (so ***P*** = 31 on the left and ***P*** = 35 on the right). This rule creates prickly *porcupine polygons* instantaneously as the parameters are adjusted. The ability to make such changes quickly and effortlessly allows users to modify the appearance of the image even though they might not understand (or care about) the math behind such changes. (Focus on *images,* not *explanations,* in your initial reading of 1.1.1 and 1.1.2.)





Electronic String Art. ESA examines string art on a closed circuit. A closed circuit simply means that the last vertex connects to the first. By tying the vertices to equally spaced coordinates on a circle and thereby having vertices that create regular polygons or stars, ESA completely removes the necessity for users to worry about the location of the vertices. All the user needs to do is decide the number of vertices, ***n***, their polygon should have or how many jumps, ***J***, between vertices their ***n***,***J***-star should have. User choices (of ***n*** and ***J***) set up the frame on which the subdivision nails, ***S***, are set. Lastly, a counting rule ***P*** is chosen. ESA becomes accessible to users well before they learn about graphing in late elementary/early middle school. To change values, users need only click ⬍ arrows and watch what happens. The above examples had ***J*** = 1 and so all the nails were on the edge of the polygon, a 9-gon for L1 and a hexagon (6-gon) for R1. L2 and R2 change ***J*** to 2 (left) and ***J*** to 4 (right) using the ***n*** = 9, ***S*** = 7, and ***P*** = 31 values from L1.

If ***J*** > 1, 9-point stars may result. The images are in 2 rows: the top shows **circle (purple)**, **vertex labels (red)**, **star (blue)**, **nail locations (red)** and **first line of the image**; the bottom removes these *structural elements* and shows only the image. The L1 **63**-nail 9-gon image becomes L2, a **63**-nail **9,2-star**, or R2, a **63**-nail **9,4-star** by changing ***J*** from 1 to 2 to 4.



Note that some of the top row **nails** almost coincide. This near coincidence shows up in the bottom images: in L2, the 4th line drawn from a vertex is very short; in R2, the inner parts of the small 9,3-star in the center are very close to one another but do not touch. Examples of both are **circled in green**. Like L1, the L2 and R2 images use 63 connected lines.

Sections in ESA are small and targeted at specific topics. Some sections are connected, like this one and the next, 1.1.2.