Figure 4.1: The cylinder, due to its slight height advantage, is the only shape that engages two fingers simultaneously. While the third finger is engaged during the grasp, its tactile sensors are not engaged. Thus, it is possible to detect contact even without tactile sensor support.

Figure 4.2: The cylinder was grasped by F2 at its base. One side of the tactile sensors at the base was not engaged during the grasp.
Figure 4.3: Notice that tactile sensors of F3 are not engaged in spite of the fact that F3’s strain sensors are active.

Figure 4.4: Tactile sensors of the palm located on the right side, beneath F2’s tactile sensor array, are engaged at grasp time.
Figures

**Figures #2: Triangular Prism**

Strain experienced by all Fingers (F1-3) and Spread (F4)

Figure 4.5: Slight tremor is experienced by F1 and F3 while the grasp is taking place.

Tactile Sensor Output for F2

Figure 4.6: Surprisingly, the way in which the triangular prism was grasped was in such a way that it nestled nicely within the shape of F2, without tactile contact. Again, in spite of a lack of tactile feedback, we still obtain object shape information from the fact that F2’s strain sensors are active.
Figure 4.7: Contact surface area was greatest for the triangular prism and thus engages a larger number of tactile sensors on the palm. This is also due to the way in which the object was oriented when a stable grasp was secured.

Figures #3: Cube

Figure 4.8: Similar as with the triangular prism, a slight tremor is experienced by F1 and F3 during the grasp that primarily engages F2.
Figure 4.9: The cube was grasped in such a way that one of its corners was embedded into the tactile sensor array of the finger and palm. This demonstrates that the hand is capable of stable force closure even when the object is oriented in an unstable fashion.

Figure 4.10: The cube was grasped with one of its corners embedded into the tactile array of the palm. This explains why the response is quite different to that of the triangular prism, whose surface area on each side is similar.
The phases indicated were common for all lifting trials: a - preload phase; b - loading phase; c - transitional phase; d - static phase; e - replacement phase; f - delay; g - unloading phase. Force ratio not shown for the preload phase in Johansson and Westling’s results.

Circled areas denote transition conditions.

Note the interrupted time scales.

Forces were measured as torques in our experiment since grip force is measured as strain torque on the BarrettHand.
Table 4.1: Tactile sensor output from finger F3 (a) and palm (b) during our action-phase experiment