Review on “early enclosure”

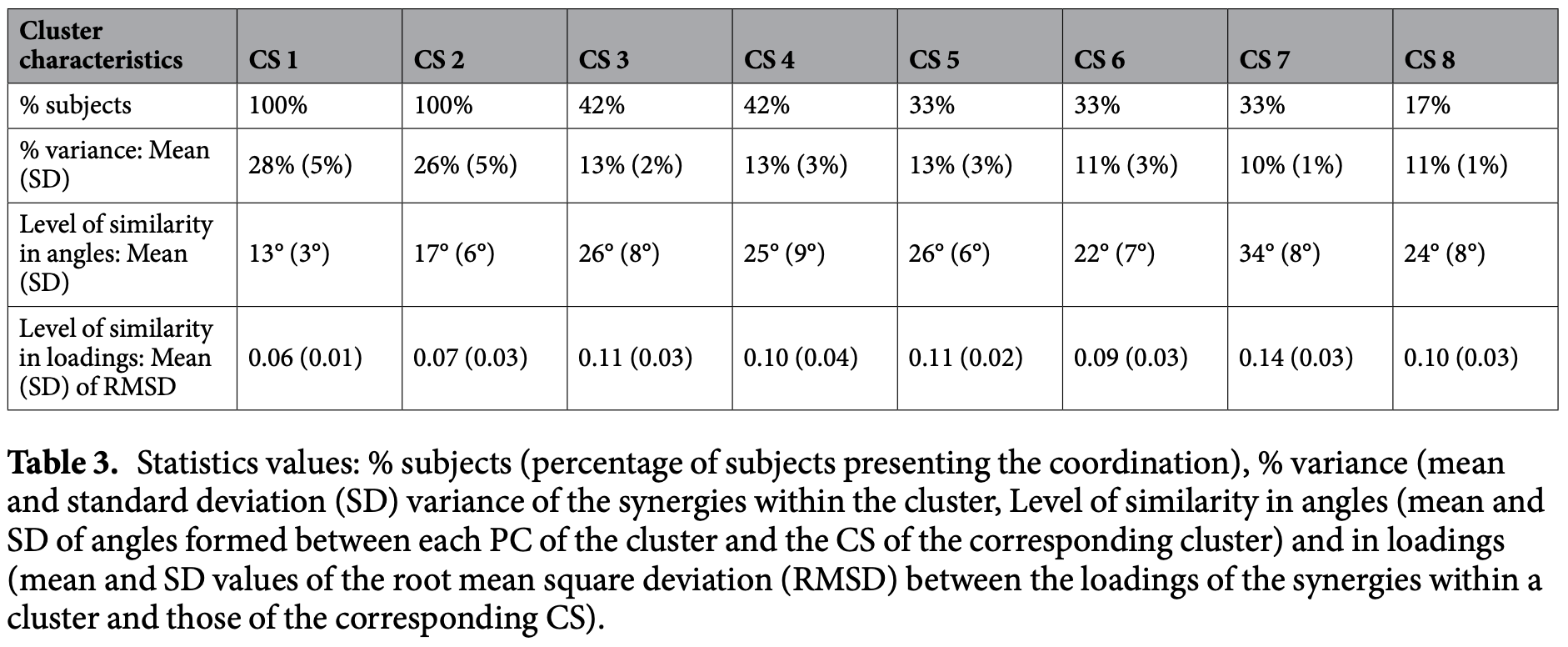
Those papers marked (\*) are the most relevant for us

Hand synergies during reach-to-grasp [1]:

They use reach and grasp task of 16 different objects with a 3s. trial. They describe 3 stages: **static initial position, reach and grasp**. They extract 60 bins from each stage and compute the synergies **per subject without matching** synergies between subjects. The **first synergy** accounts for **>95%** of the original variance.

(\*) Sharing of hand kinematic synergies across subjects in daily living activities [2]:

Subjects perform **activities of daily living**, apparently with no time limitation. Data are resampled and 4 synergies are extracted **from each subject** and then **clustered**. Those 4 synergies accounted for **>75%** of the original subject’s data.



(\*) Multidigit movement synergies of the human hand in an unconstrained haptic exploration task [3]:

**Object exploration** of 50 objects with no time restriction. They extract 10 synergies from **each subject** and **match them manually**. With **7 synergies** they get **>90%** of the original variance, with **10 synergies** they achieve **≈95%**.

Postural hand synergies for tool use [4]:

Subjects are instructed to grasp and **imagined object**. Synergies are extracted from a **single datapoint** (the last one before the offset signal). They extract **4 synergies per subject** with **no matching**. With only **2 synergies** they can explain **>80%** of the original variance of each subject.

Using kinematic reduction for studying grasping postures. An application to power and precision grasp of cylinders [5]:

**Static grasp** of cylinders. Synergies are extracted using a **single datapoint** per trial and using **all subjects** together. **5 synergies** account for **>82%** of the original variance.

(\*) Postural hand synergies during environmental constraint exploitation [6]:

They extract synergies from a **single datapoint** from pre-shape and contact phase (**multipoint**) using **all subjects** in both cases. For pre-shaping **3 synergies** explain **≈70%** of the original variance, for contact **3 synergies** account for **≈<70%**.

Analysis of hand synergies in healthy subjects during bimanual manipulation of various objects [7]:

Synergies are extracted from **two datapoints** of each trial (give & receive) from **all subjects**. Since they have two gloves, one is projected into the other side. **4 synergies** account for **>95%** of the original variance.

(\*) Analysis of the synergies underlying complex hand manipulations [8]:

Synergies extracted from **all subjects** and **entire trials** while manipulating **common objects**. They need **6-8 synergies** to explain **85%** of the original variance and **9-12** to explain **95%** (with an original space of 20 joints).

(\*) Kinematic synergies of hand grasps: a comprehensive study on a large publicly available dataset [9]:

Synergies are extracted from **grasps on common objects**. They extract the synergies from **each subject** and build **clusters**. They need **9 synergies** to reach the **70%** of the original space, **12 synergies** for **80%**, **16** for **90%** and **18** for **95%.** It is worth to notice that the original joint space is 17, so the synergistic space is higher than the original due to the non-shared synergies.

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[2] V. Gracia-Ibáñez, J. L. Sancho-Bru, M. Vergara, N. J. Jarque-Bou, and A. Roda-Sales, “[Sharing of hand kinematic synergies across subjects in daily living activities](https://link.springer.com/content/pdf/10.1038/s41598-020-63092-7.pdf),” *Sci. Rep.*, vol. 10, no. 1, pp. 1–11, 2020, doi: 10.1038/s41598-020-63092-7.

[3] P. H. Thakur, A. J. Bastian, and S. S. Hsiao, “[Multidigit movement synergies of the human hand in an unconstrained haptic exploration task](https://www.jneurosci.org/content/28/6/1271.short),” *J. Neurosci.*, vol. 28, no. 6, pp. 1271–1281, 2008, doi: 10.1523/JNEUROSCI.4512-07.2008.

[4] M. Santello, M. Flanders, and J. F. Soechting, “[Postural hand synergies for tool use](https://www.jneurosci.org/content/18/23/10105.short),” *J. Neurosci.*, vol. 18, no. 23, pp. 10105–10115, 1998, doi: 10.1523/jneurosci.18-23-10105.1998.

[5] N. Jarque-Bou, V. Gracia-Ibáñez, J. L. Sancho-Bru, M. Vergara, A. Pérez-González, and F. J. Andrés, “[Using kinematic reduction for studying grasping postures. An application to power and precision grasp of cylinders](https://www.sciencedirect.com/science/article/pii/S0003687016300370?casa_token=nk1Fm-bUoZAAAAAA:fksiX7E6Hw_DOchGzYF9-eeRdPoWm3FySYVS1uIYYGQH_7b2rUSvVl6jq2GglccW_QcJWnWFNGQ),” *Appl. Ergon.*, vol. 56, pp. 52–61, 2016, doi: 10.1016/j.apergo.2016.03.003.

[6] C. Della Santina *et al.*, “[Postural hand synergies during environmental constraint exploitation](https://www.frontiersin.org/articles/10.3389/fnbot.2017.00041/full),” *Front. Neurorobot.*, vol. 11, no. August, pp. 1–14, 2017, doi: 10.3389/fnbot.2017.00041.

[7] N. Jarrassé, A. T. Ribeiro, A. Sahbani, W. Bachta, and A. Roby-Brami, “[Analysis of hand synergies in healthy subjects during bimanual manipulation of various objects](https://link.springer.com/article/10.1186/1743-0003-11-113),” *J. Neuroeng. Rehabil.*, vol. 11, no. 1, pp. 1–11, 2014, doi: 10.1186/1743-0003-11-113.

[8] E. Todorov and Z. Ghahramani, “[Analysis of the synergies underlying complex hand manipulation](https://pubmed.ncbi.nlm.nih.gov/17271341/),” *Annu. Int. Conf. IEEE Eng. Med. Biol. - Proc.*, vol. 26 VI, pp. 4637–4640, 2004, doi: 10.1109/iembs.2004.1404285.

[9] N. J. Jarque-Bou, A. Scano, M. Atzori, and H. Müller, “[Kinematic synergies of hand grasps: A comprehensive study on a large publicly available dataset](https://link.springer.com/article/10.1186/s12984-019-0536-6),” *J. Neuroeng. Rehabil.*, vol. 16, no. 1, pp. 1–14, 2019, doi: 10.1186/s12984-019-0536-6.