

Future or Fugazi? The Promise of Technology in Healthcare

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Fugazi.

It's a whazy, It's a woozie.

It's fairy dust. It doesn't exist.

It's never landed.

It is no matter.

It's not on the elemental chart.

It's not f-ing real





NHS

The Topol Review

Preparing the healthcare workforce to deliver the digital future

An independent report on behalf of the
Secretary of State for Health and Social Care
February 2019



LYLE'S BLACK TREACLE

ABRAM LYLE & SONS



OUT OF THE STRONG CAME FORTH SWEETNESS

SUGAR REFINERS

454g e

Made from Cane Molasses: a source of minerals



CULTURE EATS STRATEGY FOR BREAKFAST

Peter DRUCKER

m



“The **third culture** consists of those scientists and other thinkers [...] who, [...] are taking the place of the traditional intellectual in rendering visible the deeper meanings of our lives, redefining who and what we are”

John Brockman

What Does Medicine Want?

ARTIFICIAL INTELLIGENCE



Machine Learning

machine learning techniques. Artificial intelligence, which encompasses machine learning, is the scientific discipline that uses computer algorithms to learn from data, to help identify patterns in data, and make predictions. A key feature underpinning the excitement

Collins & Moons, Lancet, 2019

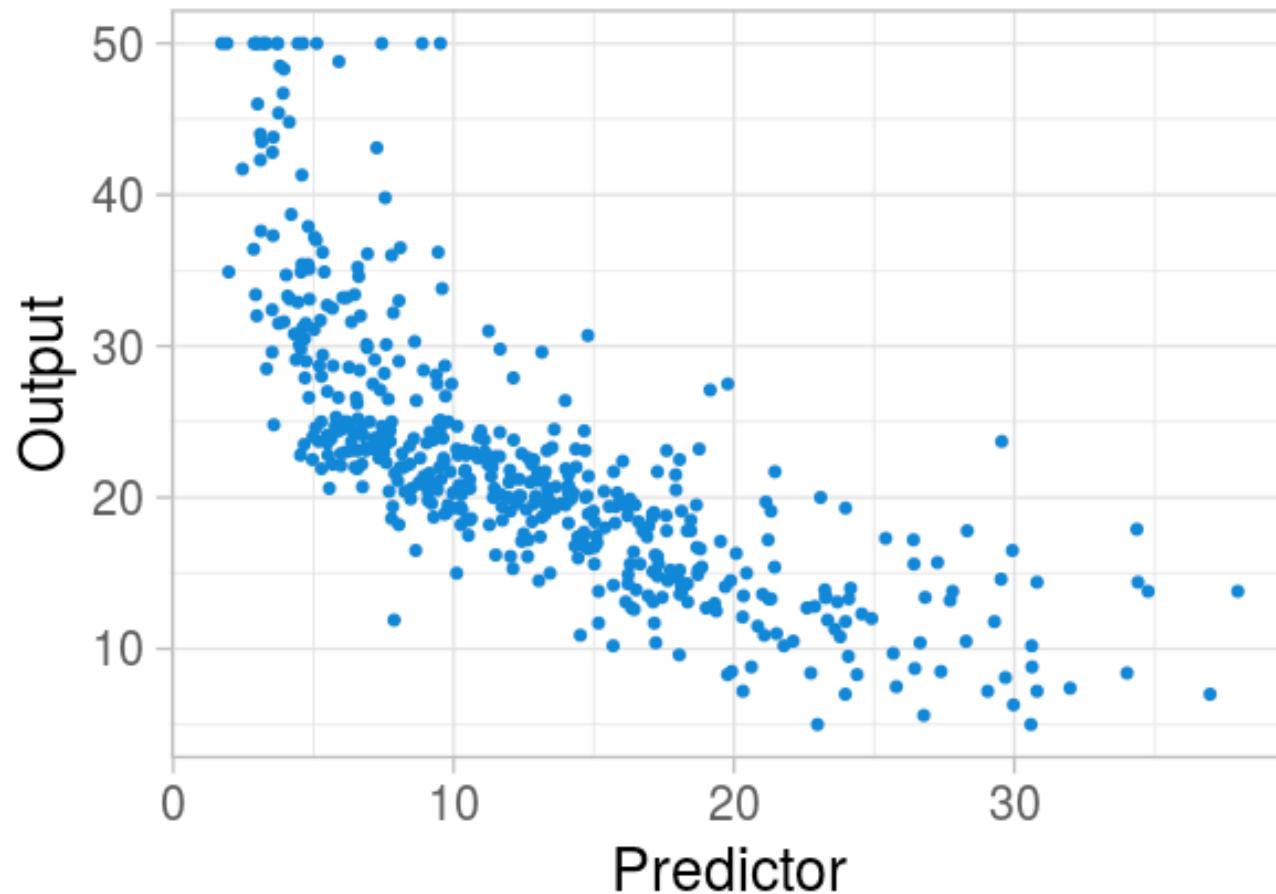


Caution

Images of statistical concepts and light
mathematics approaching

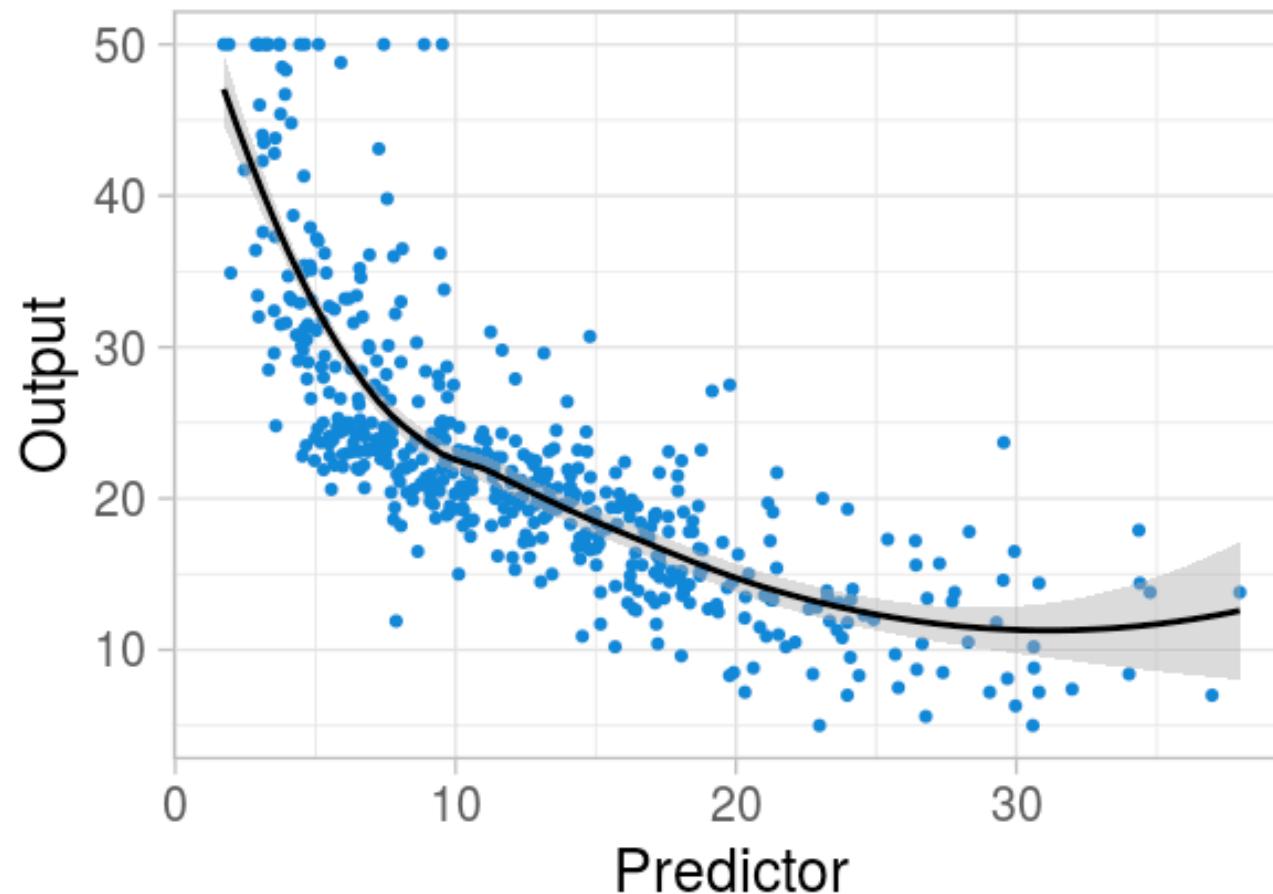
Viewers of a sensitive disposition are advised
to proceed with caution

Using Data to Predict



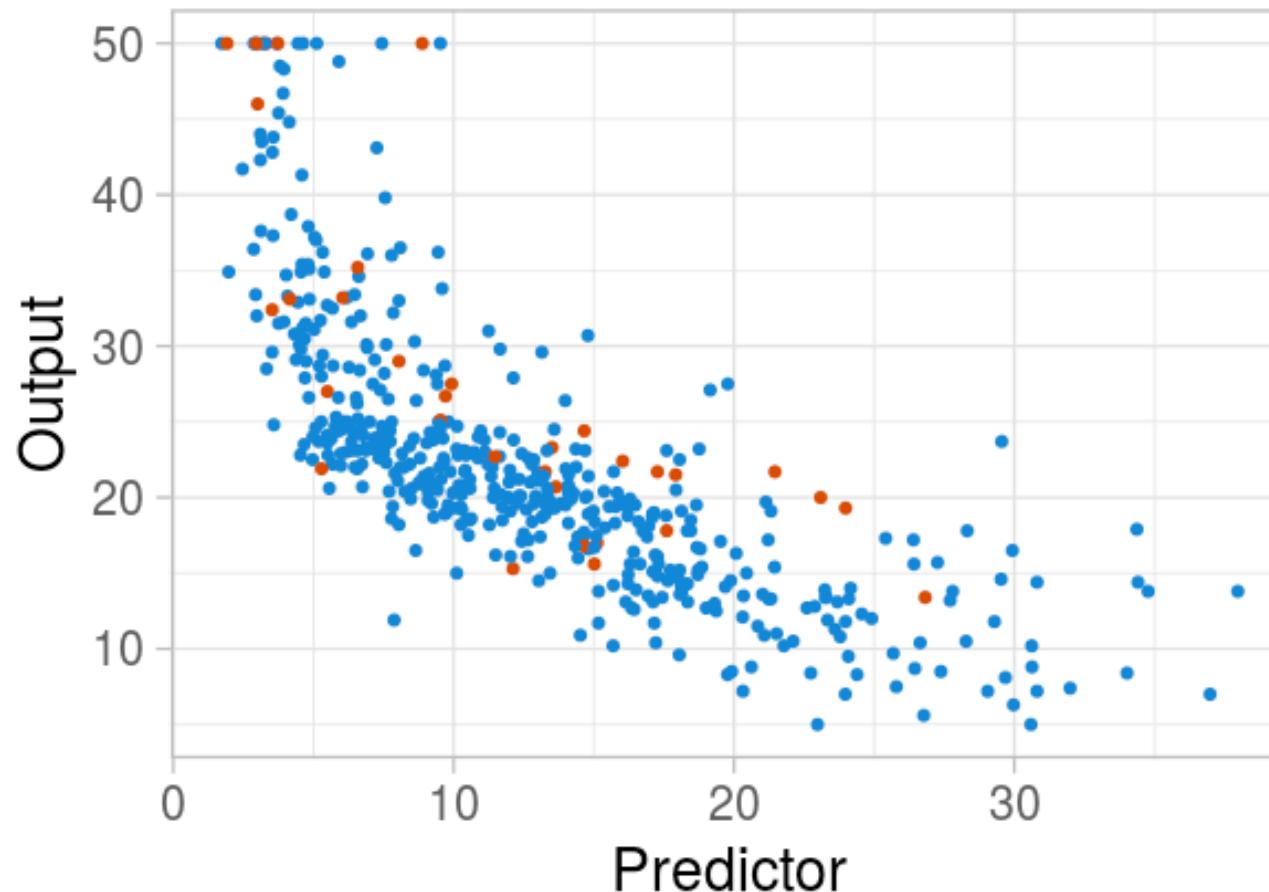
Using Data to Predict

$$y = f(x) + \varepsilon$$



Using Data to Classify

Machine Learning deals in overall prediction



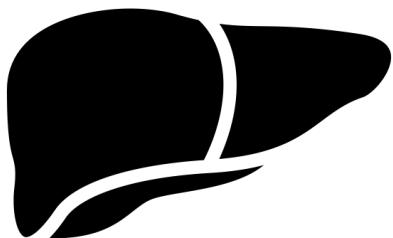
Technology that allows computers to perform
specific tasks by learning from data & not
following pre-programmed rules

The Promise of Machine Learning?



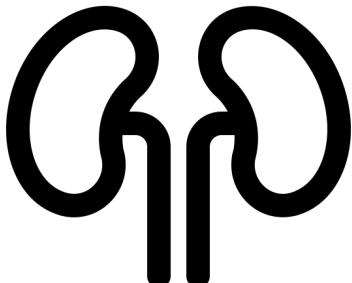
Prediction of Coronary Heart Disease Using Risk Factor Categories

Wilson *et al.*, Circulation, 1998



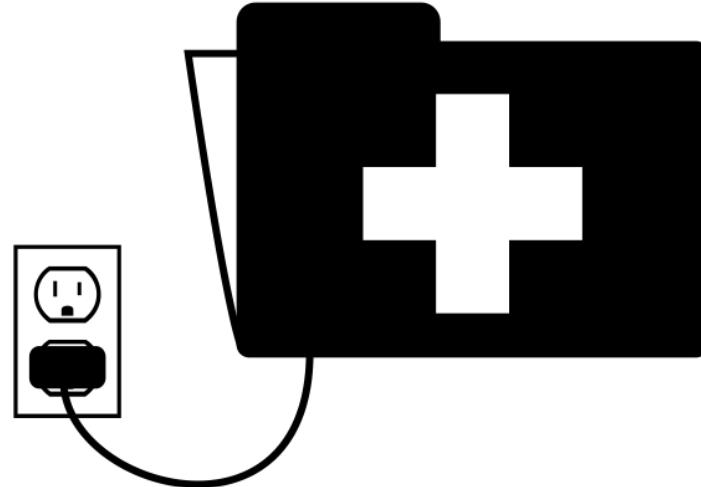
A Model to Predict Poor Survival in Patients Undergoing Transjugular Intrahepatic Portosystemic Shunts

Malinchoc *et al.*, Hepatology, 2000



A Predictive Model for Progression of Chronic Kidney Disease to Kidney Failure

Tangri *et al.*, JAMA, 2011



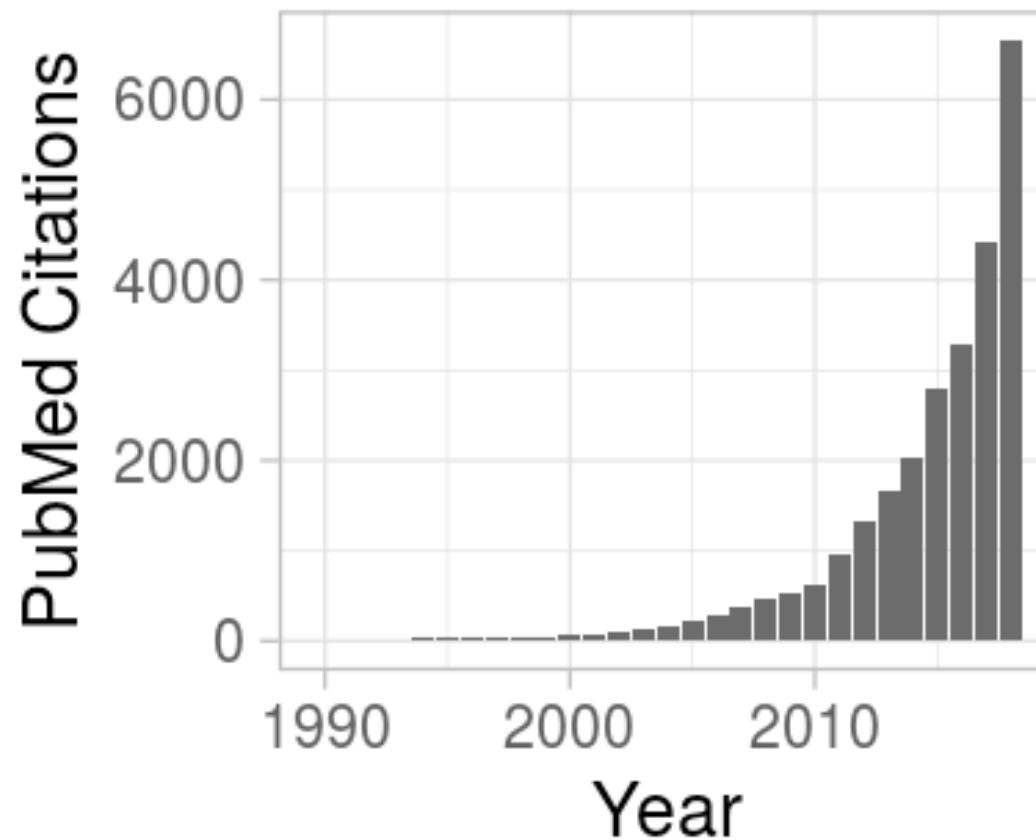
A New Era in Healthcare

Many Participants

Many Predictors

New Relationships

The Promise of Machine Learning



Clinical Medicine isn't Classification

Medical decisions are:

- Not classification problems
- Made at the point of care
- Subject to change

Medical data has:

- Biological variation
- Sampling Variability
- Measurement Errors
- Different Treatments

Specialty	Images	Publication
Radiology/Neurology	CT head, acute neuro events	Titano, Nature Medicine, 2018
	CT head for brain hemorrhage	Arbabshirani, NPJ (Nature) Digital Medicine, 2018
Pathology	Breast cancer	Bejnordi, JAMA, 2017
	Brain tumors (+ methylation)	Capper, Nature, 2018
Dermatology	Skin cancers	Esteva, Nature, 2017
	Melanoma	Haenssle, Annals of Oncology, 2018
Ophthalmology	Skin lesions	Han, Journal of Investigative Dermatology
	Diabetic retinopathy	Gulshan, JAMA, 2016
	Diabetic retinopathy	Abramoff, NPJ (Nature) Digital Medicine, 2018
	Congenital cataracts	Long, Nature Biomedical Engineering, 2017
	Retinal diseases (OCT)	De Fauw, Nature Medicine, 2018
	Macular degeneration	Burlina, JAMA Ophthalmology, 2018
	Retinopathy of Prematurity	Brown, JAMA Ophthalmology, 2018
	AMD and diabetic retinopathy	Kermany, Cell, 2018
Gastroenterology	Polyps at colonoscopy	Mori et al, Annals Internal Medicine, 2018
Cardiology	Echocardiography	Madani, NPJ (Nature) Digital Medicine, 2018



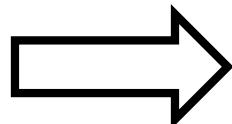
Most predictions about the future of artificial intelligence suggest two possibilities: AI will either make us immortal or it will hasten our extinction. *Aniara* posits a third option: the unredeemable awfulness of humanity drives an artificial intelligence to suicide. From the country that gave us Greta Thunberg comes EHR data

Will ML Improve on Standard Statistical Methods?

Modern modelling techniques are data hungry: a simulation study for predicting dichotomous endpoints

Van der Ploeg *et al.*, BMC MRM, 2014

Outcome	Cohort		
	HNSSC	TBI	CHIP
5 year survival	6 months mortality	Intracranial findings	
dichotomous	dichotomous	dichotomous	
601/1282 (46.9%)	386/1731 (22.3%)	243/3181 (7.6%)	
2 dichotomous	4 dichotomous	9 dichotomous	
4 categorial	1 categorial	1 categorial	
1 continuous	4 continuous	2 continuous	



DATA HUNGER
>10x as many outcome events per input variable

Predicting the risk of chronic kidney disease in the UK:

an evaluation of QKidney® scores using a primary care database

Collins & Altman, BJGP, 2012

Mod to Severe CKD 2.7%

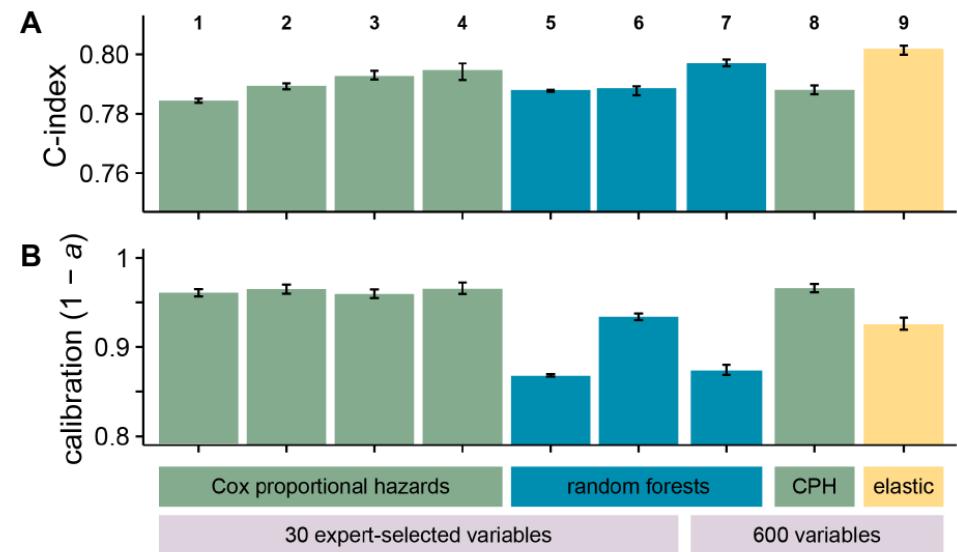
ESRF 0.17%

Delivering On The Promise

RESEARCH ARTICLE

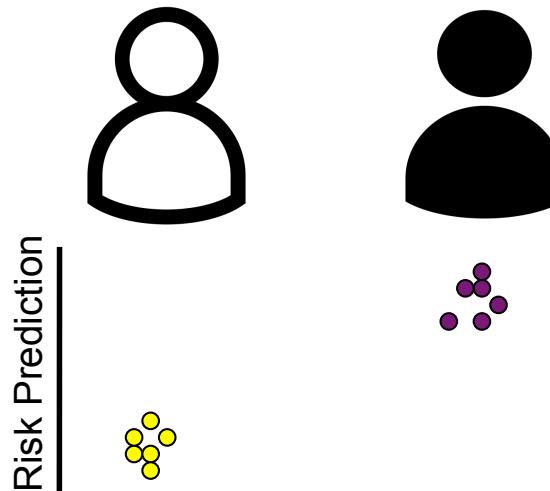
Machine learning models in electronic health records can outperform conventional survival models for predicting patient mortality in coronary artery disease

Andrew J. Steele^{1*}, Spiros C. Denaxas², Anoop D. Shah^{2,3}, Harry Hemingway², Nicholas M. Luscombe^{1,4,5}



What Is Sustaining The Hype?

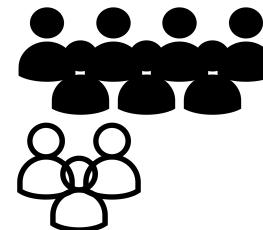
Discrimination



Ability to differentiate between
“outcomes” & “non-outcomes”

Calibration

70% Risk Prediction



How closely prediction of
outcomes matches actual
outcomes

A systematic review shows no performance benefit of machine learning over logistic regression for clinical prediction models

Christodoulou *et al.*, J Clin Epi, 2019

Discrimination Biased assessment

Calibration Not assessed 79%

Delivering On The Promise

RESEARCH ARTICLE

Machine learning models in electronic health records can outperform conventional survival models for predicting patient mortality in coronary artery disease

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AI BEATS DOCTORS AT PREDICTING HEART DISEASE DEATHS

4 SEPTEMBER 2018 | [HUMAN BIOLOGY](#) | [HEALTH AND AGEING](#) | [NEWS](#)

Summary

AI/ML approaches probably will change how we do highly replicable things

Advantages of ML over classical statistics probably won't be realised until we address data accessibility and sharing

Big data usage in healthcare requires statistical rigour & methodological honesty

“A medical device with a plausible sales pitch is a very hard thing to counter with mere evidence”

Richard Lehman June 2018

Acknowledgments

- The slides and data for the finance and Pubmed plots are available on my github page:
[toates19/Future-or-Fugazi](https://github.com/toates19/Future-or-Fugazi)
- There is a full list of acknowledgments there but briefly, this talk owes a debt to:
 - Bad Blood by John Carreyrou for the financial background
 - Evgeny Morozov's writing about the Third Culture
 - Maarten van Smeden's talk at IBS ROeS



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