The ToyBox Study and changing children's preferences for healthy snacks: what is the evidence?

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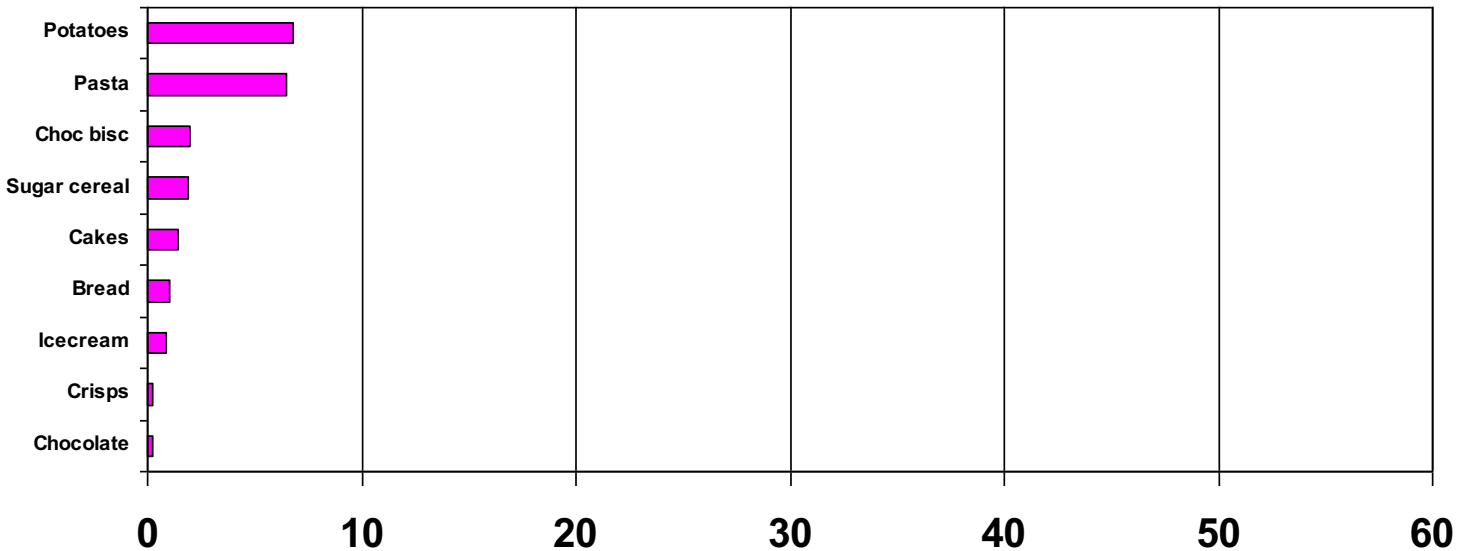
Objectives

- Development of children's food preferences:
  - Innate reflexes; genetic factors; sensory factors
  - Learning: associative, non-associative, social
- ToyBox Study (intervention in 4-6 y.o. children)
  - Background
  - Evidence-based design
  - Methods
  - Findings

What determines children's food and drink choices?

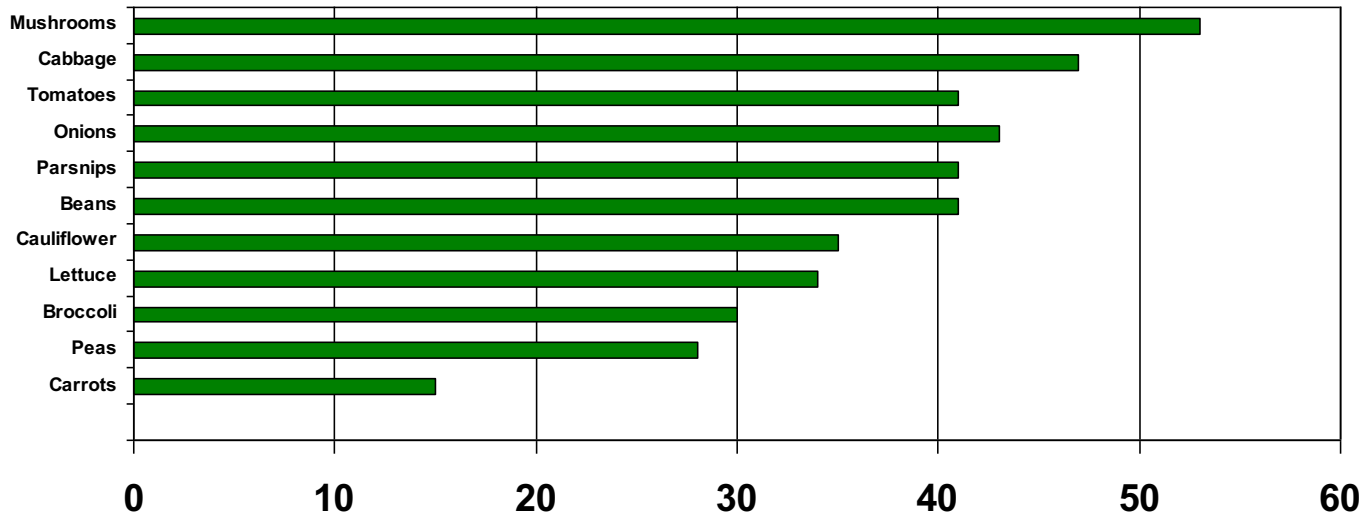
- Innate predispositions (e.g. genes)
- Temperament (neophobia, reward sensitivity, etc.)
- Experience/learning – including *in utero* and early postnatal experience (breast vs. formula; weaning practices)
- Characteristics of food/drink itself
- The behaviour of parents, peers (parenting style, modelling, feeding practices)
- The (family) environment (sociocultural, economic, siblings)

% of 4-5-year-old children NOT liking starchy, fatty and sugary foods



(Wardle et al, 2001: Figure courtesy of Lucy Cooke, UCL)

% of 4-5 year-old children NOT liking vegetables



- NB: F&V intake associated with better hydration status in children (Montenegro-Bethancourt et al., 2013)

(Wardle et al, 2001: Figure courtesy of Lucy Cooke, UCL)

Innate reactions to taste

- Humans are born with very few pre-determined food and flavour preferences…
- …but preference for sweet taste and the rejection of bitter (and sour?) tastes appear to be innate (adaptive?)
- This can be seen quite clearly in the facial responses of newborns and very young babies (e.g. Steiner, 1977, 2001)
- Children prefer sweeter, and less bitter, drinks/tastes than adults (e.g. Mennella & Bobowski, 2015)

Widespread innate reactions to sweet, sour and bitter tastants in neonate mammals (cp. Steiner et al., 2001) (except cats – obligate carnivores)

(Picture from Geowissen, 2001, #28)

Pre-natal influences

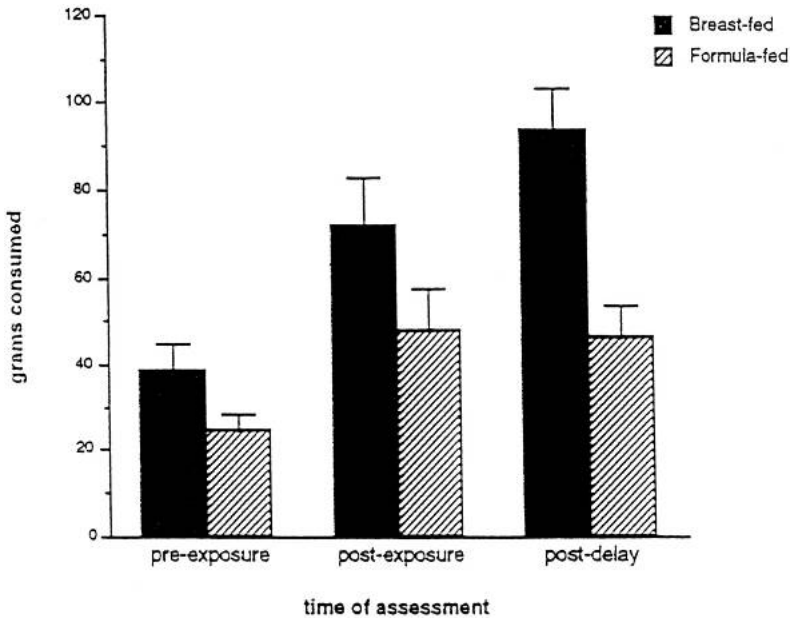
- Intrauterine environment, including mother's diet, may 'programme' foetus and alter appetite, physiological responses to food including growth and obesity risk (e.g. Ross & Desai, 2013; Koletzko et al., 2017)
- Maternal protein and fat intake during pregnancy predicted children's macronutrient intakes at 10 years old, more strongly than paternal intakes or maternal postnatal intake (Brion et al., 2010)
- Morning sickness may increase salty taste preferences in children (Leshem, 1998)
- Exposure to vegetable flavours from maternal diet via amniotic fluid increased acceptance of those vegetable dishes on weaning (Mennella et al., 2001)

Early Post-natal influences

- Exposure to (vegetable) flavours in breastmilk may make subsequent acceptance of those flavours, and vegetables, more likely (Mennella & Beauchamp, 1993, 1999; Mennella et al., 2001).
- This could explain greater acceptance of veg and fruit during weaning in breast- vs. formula-fed babies (Forestell & Mennella, 2007; Sullivan and Birch, 1994).
- May also explain some evidence that regular breastfeeding is associated with less food fussiness (Galloway et al., 2003; Shim et al., 2011) and a healthier and more varied diet in preschool children (Jones et al., 2015; large study adjusting for confounds).

Exposure learning: 8 exposures to puréed beans enhances intake in breast-fed babies only

Sullivan & Birch (1994):



[Exposure to flavours in first 4 months is most effective (Mennella et al., 2011)]

- Learning before birth: amniotic fluid (and breast milk) exposure to flavours changes preferences (e.g. Mennella et al., 2001)

UCL Twin Studies – Heritability Results for Food Preferences, Food Fussiness and Emotional Eating

- Moderately high heritability for preferences for nutrient-dense foods (48-54%; protein-rich, veg, fruit) vs. dairy, snacks, starchy foods (27-32%) (Fildes et al., 2014) – cp. Selectiveness of food fussiness/neophobia…
- In young children, the main non-genetic influence is from the shared family environment (Fildes et al., 2014, 2016), whereas in young adults it is the unique environment, with very little influence of the family environment (Smith et al., 2016) – reflecting greater independent food selection.
- Food fussiness and liking for fruits and vegetables may share genetic components (Fildes et al., 2016).
- Emotional over- or undereating (in 5 y.o.) are environmentally acquired, not genetic (Herle et al., 2017).

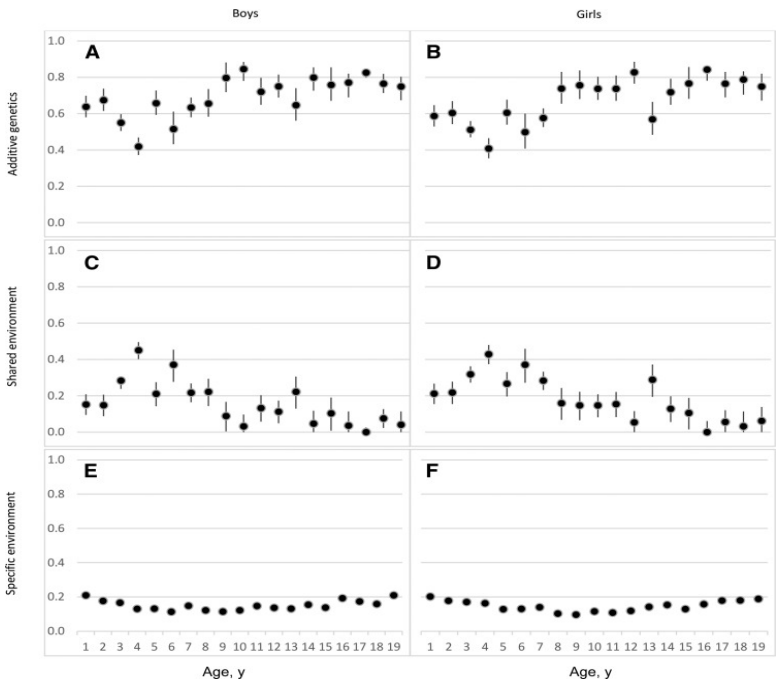
Genetic vs. Environmental Influences on Body Mass Index in Children – Variation with Age

- **Silventoinen, K., et al. (2016):** Huge analysis of 45 Twin Cohorts (CODA Twin Study) across 4 continents (N. America, Australia, Europe, Asia).
- 87,782 twin pairs
- 0.5 to 19.5 years old
- 383,092 BMI measurements
- Genetic contribution (heritability) to BMI variance is lowest at 4 years old (0.42), when shared environment is highest (0.44).
- Genetic contribution is highest (0.75), and shared environment lowest (non-existent), from mid-teens (at least until middle age).
- Genetics contributions were broadly similar across the 4 continents despite variation in obesogenic environments.

Genes

Shared Envt.

Unique Envt.

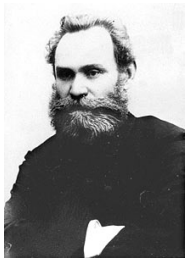


Responses to sensory characteristics of foods (Sugar, Bitter, Salt, Fat… Texture)

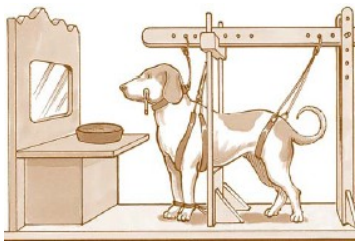
- Innate preference for sweet and aversion to bitter / sour
- Salt (Na) appetite appears innate in rats, but less clear in humans (infants indifferent to saline before 4 mo, but not 'need' tested?) – modified by experience, incl. *in utero* (e.g. morning sickness). Appetite for salty taste may reflect other deficiencies in e.g. Ca, Fe, protein…
- Bitterness: some genetic influence on bitter sensitivity conferred by TAS2R38 taste receptor genotype; predicts preference for higher sucrose levels in food and drink (Mennella et al., 2005; Timpson et al., 2007; Pawellek et al., 2016) and rejection of bitter vegetables (Bell & Tepper, 2006; Turnbull et al., 2002). Also linked to detection of sweetness at lower threshold (Joseph et al., 2016); and bitter taste sensitivity in older children predicts less weight loss following an intervention (Sauer et al., 2017).
- Sourness preference also linked to genetic polymorphisms (Chamoun et al., 2018)
- Texture: infants should experience variety (lumps!) before 10 mo. (cf. ALSPAC) to prevent texture aversion
- Fatty texture is rapidly liked – innate or fast learning?
  - Evidence for 'tasting' of fatty acids ("oleogustus") (Gilbertson et al, 1997; Running et al., 2015), but not clearly related to food preferences or obesity (Tucker et al., 2017 meta-analysis)

Moving on from unlearned responses - Forms of learning involved in control of appetite and eating

(e.g. Booth, 1985; Gibson & Brunstrom, 2007; Hargrave, Jones & Davidson, 2016)



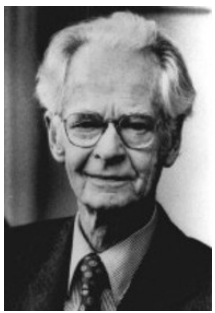
I.P. Pavlov



- **Non-associative learning**: exposure, familiarity, habituation

- **Associative Learning** (association between events/stimuli):
  - Pavlovian (Classical) Conditioning
    - **flavour-consequence [nutrient]** (e.g. We learn to like flavours predicting energy)
    - **flavour-flavour** (e.g. we learn to like flavours paired with sweetness)

- Operant (instrumental) Conditioning (actions determined by outcomes; rewards encourage behaviour)
  - e.g. Foraging, food choice, motivation



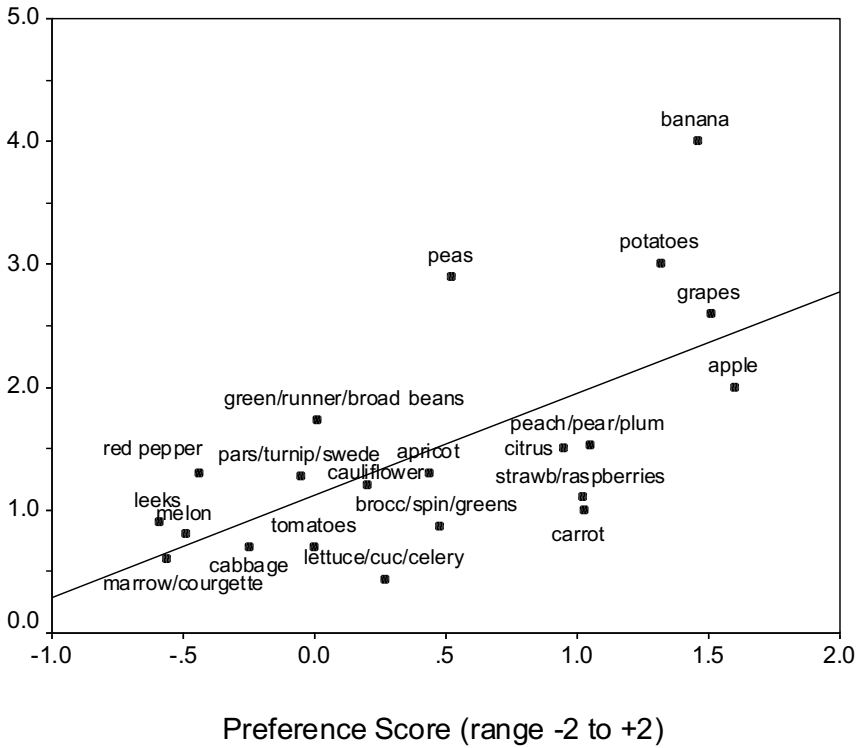
B.F. Skinner

What is positively reinforcing about food or drink?

- Taste, especially sweetness
- Energy content
  - Primary reason why kids are not keen on vegetables
- Other nutrient content, when lacked
  - Protein
  - Essential amino acids
  - Vitamins
  - Sodium, iron, calcium,
  - other essential micronutrients?
- Water, if thirsty? (cp. Durlach et al., 2002)

Energy Density of Fruit and Vegetables Predicts 42% of Variance in Preferences of 4-year-old Children*

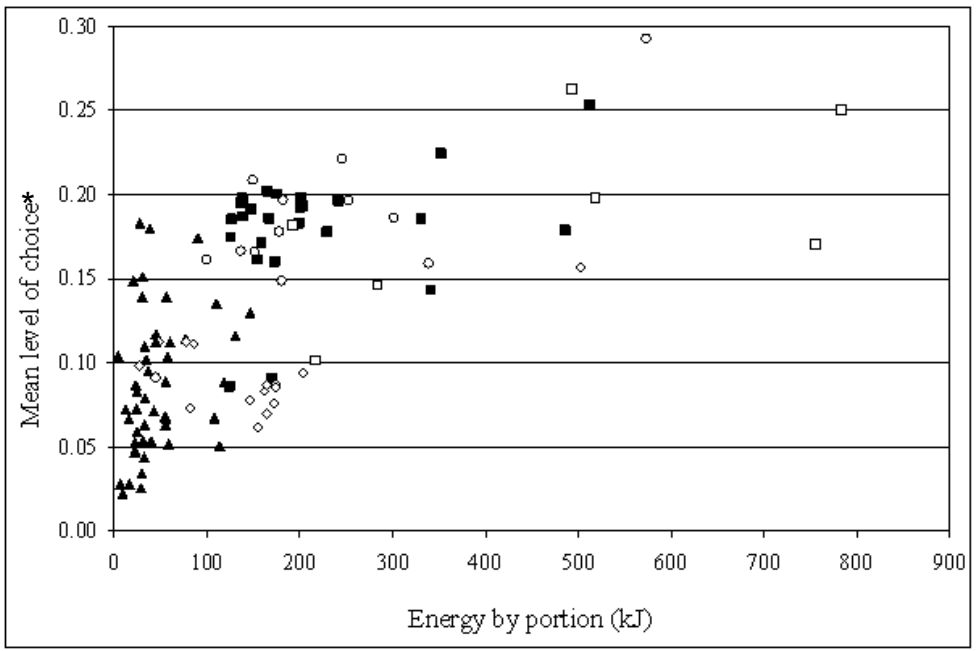
*Mother's ratings of children's likings (N range: 228 – 416, depending on exposure)



(Gibson & Wardle, 2003)

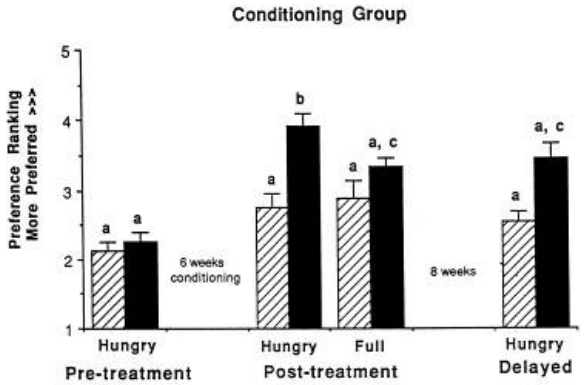
Similar finding in 2-3 year-olds for a variety of foods (Nicklaus et al., 2005)

*Ratio of average portions of food chosen to total portions eaten



▲: vegetable; O: starchy food; ◇: dairy product; ■: animal product; □: combination food

Children learn to prefer flavour of a high-fat vs. low-fat yoghurt version when hungry



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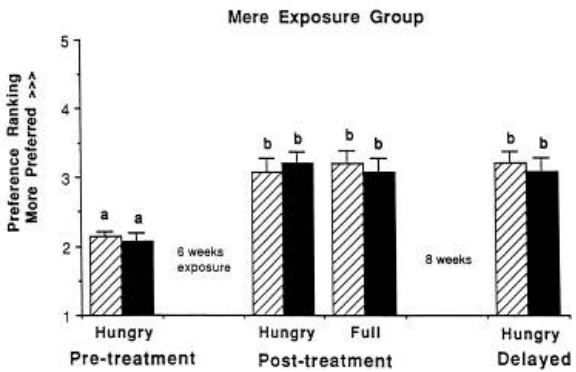


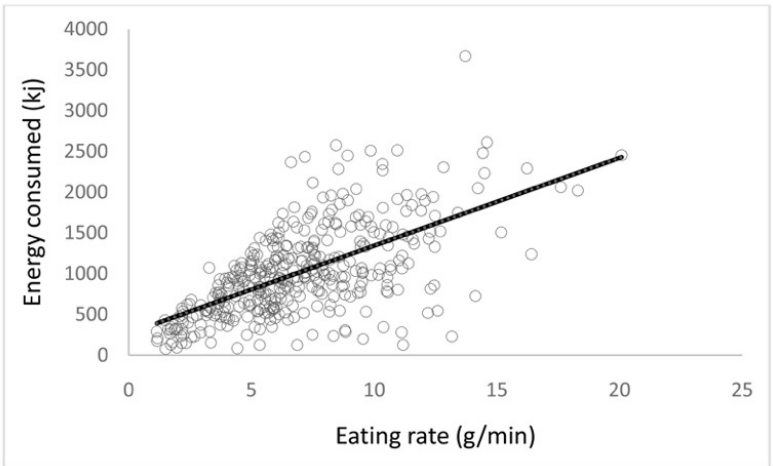
Low fat

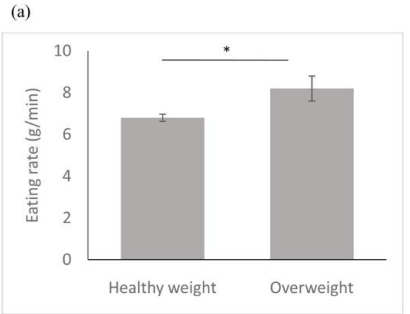
High fat

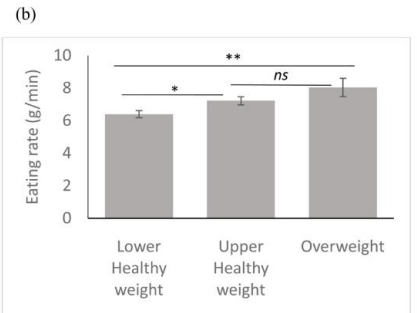
Child temperament

- **Food neophobia**: a component of picky/fussy eating (Smith et al., 2016) (prevalence 5-50% of kids, depending on age and definition) – linked to anxiety, shyness; high heritability at peak age (75-78%; Cooke et al., 2007; Fildes et al., 2016; also, Gibson & Cooke, 2017 review)
  - Manifests as a trait avoidance of unfamiliar foods, *"I don't like it, I've never tried it"*
  - Expression varies with age, peaking between 2 and 6 years (but continues to adulthood)
  - Likely inversely related to enjoyment of food
  - Perhaps related to 'sensory sensitivity' (Steinsbekk et al., 2017)
  - Related to mothers' anxiety levels (de Barse et al., 2016)
  - Quite resistant to intervention: overt maternal control may *increase* neophobia (Jarman et al., 2015)
  - Risk for obesity may be lower – fussiness more likely associated with underweight (Antoniou et al., 2016) - but not good for healthiness of diet (energy-dense habit, low veg intake, less fish/meat, limited evidence for low micronutrients)

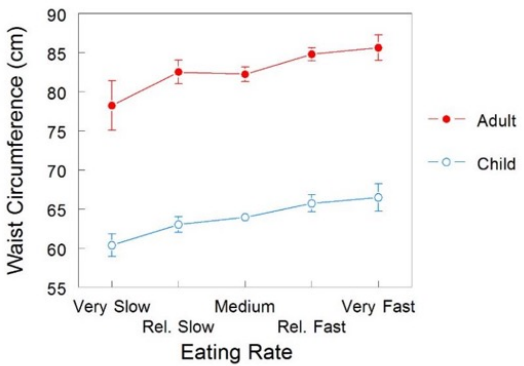
Faster eating in children associated with greater intake, larger BMI and child eating characteristics (higher food enjoyment; poorer satiation) (Fogel et al., 2017, 2018)







Gibson et al, Science Museum



Is eating rate a genetically driven response to fast growth demands?

Parenting styles: Social Learning or Modelling

- The key influence of parents' intake on their children's intake (see also Gibson et al., 1998) emphasises the importance of modelling or social learning for children (for all behaviours; innately driven)
- Basis for success of advertising (not all modelling is good)!
- Several studies and interventions have had success with modelling (reviewed by Gibson et al., 2012), but effects are strongest if:
  - ✓ Target food or drink is palatable
  - ✓ Target child is young
  - ✓ Modeller is older
  - ✓ Modeller reacts emotionally positively

Parenting styles: reacting to children's inherent tendencies?

- Parents with overweight children tend to use more restrictive and controlling feeding strategies (though overindulgent styles are also a risk for obesity), whereas pressure to eat and coercion are associated with underweight children (e.g. Birch & Ventura, 2009; Ventura & Birch, 2008).
- Parental strategies are often a response to children's eating behaviour, not a cause of it (reviewed by Gibson et al., 2012; Gibson & Cooke, 2017).
- Moderate restriction practices, including covert rather than overt methods, may lead to healthier eating and drinking than either high or low restriction (Brown et al., 2008; Jarman et al., 2015).
- Limiting drinking at meals to water may encourage vegetable intake (Cornwell & McAlister, 2013).

Key predictors of young children's adiposity - including from ToyBox-Study

- Family environment, including modelling effects (e.g. Birch & Ventura, 2009; Gibson et al., 2012; Savage et al., 2007), which is **stronger than genetic influences in pre-school children** (Llewellyn et al., 2013; Silventoinen et al., 2016), especially for snacks and dairy foods (Fildes et al., 2014).
- Appetitive traits (e.g. Carnell & Wardle, 2009; van den Berg et al., 2011); rapid early growth (Androutsos et al, 2018).
- Parental feeding practices (Birch & Ventura, 2009), though these are more often responsive to children's eating and growth (Carnell & Wardle, 2007; Gibson et al., 2012; Webber et al., 2010, 2011).
- Greater meal size and frequency (Syrad et al., 2016) [which might explain why overweight boys appear to drink more water than normal weight boys; Cardon et al., 2016].
- Screen time, sedentary behaviour (e.g. Androutsos et al., 2018; Cardon et al., 2016).
- Low parental education (Androutsos et al., 2018).
- Parental obesity; gestational weight gain; high birth weight (Androutsos et al., 2018).

Importance of Snacking for Children's Health

- Young children have disproportionately high metabolic rates (Wang, 2012) and brain energetic demands (Chugani, 1998).
- Thus, snacking between meals for these children is a normal, potentially beneficial and easily acquired habit.
- Snacks can provide one third of total energy intake in children (Wang et al., 2018).
- However, commonly marketed snack foods and drinks are often high in sugar, energy dense and highly attractive, displacing healthier options, and leading to negative health consequences and increased risk of excess weight gain (Beets et al., 2014; Taillie et al., 2015).
- Parental influences on children's snacking, and implications for obesity risk, are less well researched (Blaine et al., 2017; Corsini et al., 2018; Kral et al., 2017).

The ToyBox Study

A multifactorial evidence-based approach using behavioural models in understanding and promoting fun, healthy food, play and policy for the prevention of obesity in early childhood

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Aim

Development of a kindergarten-based family-involved intervention programme

- aim: to prevent obesity in early childhood
- target groups: teachers, children and parents
- target behaviours: drinking, snacking, physical activity and sedentary behaviour
- process guide: Intervention Mapping protocol

ToyBox-Study

Academic Research Institutes

- Harokopio University, HUA (GR)
- Ludwig-Maximilians University of Munich, LMU (DE)
- State Institute of Early Childhood Research, IFP (DE)
- Ghent University, Ugent (BE)
- VU University Medical Centre, Vumc (NL)
- University of Zaragoza, UniZar (ES)
- Akershus University College, HIAK (NO)
- Durham University, UDUR (UK)
- Roehampton University, RoU (UK)
- Children's Memorial Health Institute, CMHI (PL)
- Medical University of Varna, MUV (BG)
- University of Luxembourg (ULU) (LUX)

International / Health Promotion Organisations

- International Association for the Study of Obesity, IASO (UK)
- Netherlands Institute for Health Promotion and Disease Prevention, NIGZ (NL)

SME

- AOK- Verlag GmbH (DE)

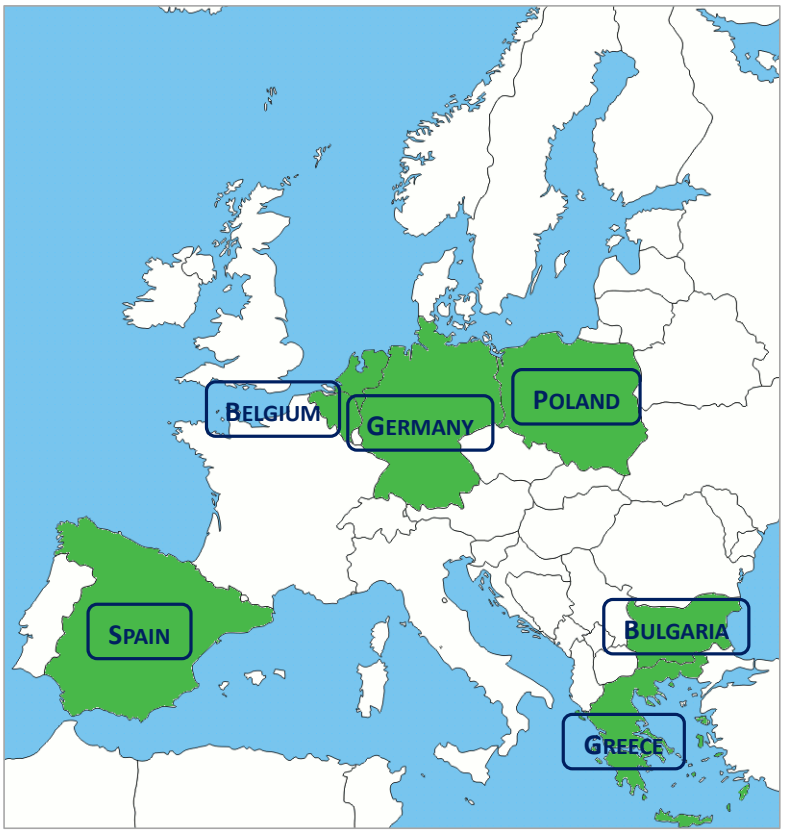
April 2010 | 2011 | 2012 | 2013 | 2014

Key points for effectiveness of interventions in children

(learnt from reviews [systematic/meta-analyses])

- guided by a systematic evidence-based approach
- rooted in behaviour change theory
- take into account the stakeholders' views, contextual factors and policy framework
- target important determinants of health behaviours
- target school and family environmental factors
- parental involvement
- duration at least 6 months
- perform a process evaluation

Intervention – 6 countries



- **266 kindergartens**
  - 176 intervention
  - 90 control
- **8709 children**
  - 5463 intervention
  - 3246 control
- **5645 children** with complete data at both baseline and follow-up

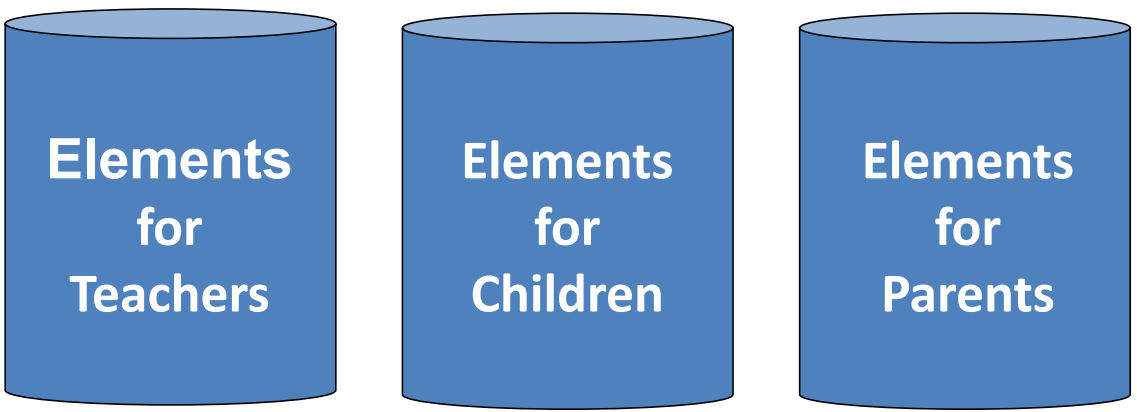
2010 | 2011 | Sept 2012 | April 2013 | 2013 | 2014

Timing of Implementation

- Set up environmental changes before kindergarten year
- Start during second week of kindergarten year
- Promotion of each behaviour for four weeks
- Repetition of each behaviour for two weeks

FIRST FOCUS				REPETITION			
4 weeks	4 weeks	4 weeks	4 weeks	2 weeks	2 weeks	2 weeks	2 weeks
DRINKING	PHYSICAL ACTIVITY	EATING AND SNACKING	SEDENTARY BEHAVIOUR	DRINKING	PHYSICAL ACTIVITY	EATING AND SNACKING	SEDENTARY BEHAVIOUR

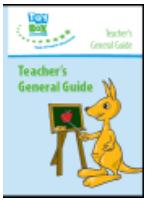
Intervention Tools



Elements for Teachers

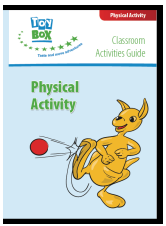
One Teacher's General Guide

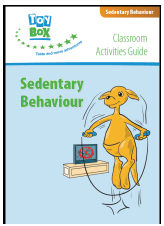
- Overview of ToyBox intervention program
- Information about implementation
- Time plan of six months intervention

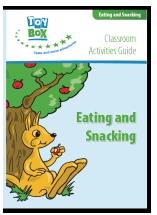


Four Classroom Activity Guides

- Each one focusing on one of the targeted behaviours
- Contain all information on how the programme should be delivered in the kindergarten class
- Uniform concept:
  Part 1: Setting environmental changes
  Part 2: Child performing the actual behaviour
  Part 3: Classroom activities







Elements for Teachers
Classroom Activity Guides: Part 1

Part 1: Setting environmental changes

- increase availability & access to healthy snacks, water and pa equipment
- rearrange the classroom for conducting safe & easy active breaks

Implementation of:

- Drinking → drinking station
- Eating & snacking → magic snack plate
- Physical activity → movement-friendly rearrangements of kindergarten
- Sedentary behaviour → rearrangements of class so that children sit down less

Elements for Teachers

Classroom Environment

Elements for Teachers
Classroom Activity Guides: Part 2

Part 2: Child performing the actual behaviour

- Daily reminders or activities for children to perform the desired behaviours
- Suggestions of methods to integrate into curriculum

Implementation of :

- Drinking → children's regular consumption of water
- Eating & snacking → scheduled healthy morning & afternoon snacks
- Physical activity → PE sessions twice/week
- Sedentary behaviour → daily movement breaks

Elements for Teachers
Classroom Activity Guides: Part 3

Part 3: Classroom activities

- Active participation to provide and increase knowledge, skills & self-efficacy
- Classroom activities to include in daily/weekly kindergarten routine
- One hour per week

Implementation of:

• Drinking	→water cup, kangaroo stories, sensory perception games, experiments, excursions
• Eating & snacking	→kangaroo stories, sensory perception games, experiments, excursions
• Physical activity	→kangaroo stories, excursions
• Sedentary behaviour	→kangaroo stories, short & longer movement breaks, movement corners

Elements for Teachers

Classroom Activity: Examples

Food groups train – nutritional education

Puppet show – role modelling of target behaviours

Elements for Teachers

Kangaroo hand puppet:
supports observational learning, role modelling

ToyBox 'Box'

Elements for Teachers

Training of Kindergarten Teachers

Aims:

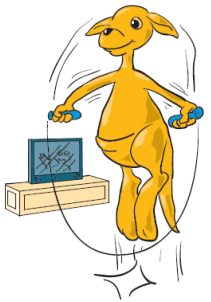
- to understand aims, concept and design
- to become familiar with material
- to become motivated and enthusiastic
- to understand the role and active participation
- share experiences and preserve motivation and enthusiasm

Procedures:

- First, second, third Training session
- Duration: 2-4 hours (depending on group size)
- Time and Location: depending of local conditions
- Participants: all teachers invited, at least one teacher per class to attend the sessions

Elements for Teachers
Teachers' Training : Pictures

Elements for Children



Active participation

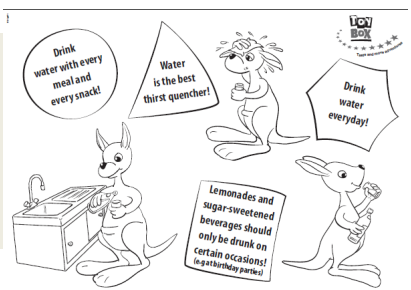
• Opportunities for children to be active and have interactive hands-on experiences

e.g. stories, PA sessions, short & long movement breaks, games, recipes, excursions …

Posters

• One poster for each behaviour

• To colour in and take home



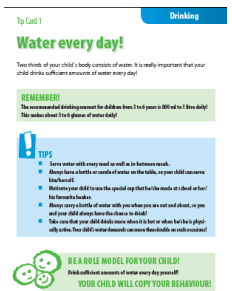
Elements for Parents

Newsletter (NL)

- 9 NL: 1 NL Introduction, 2 NL for each behaviour
- Information on theoretical background
- Information on current activities in kindergarten

Tip Card (TC)

- 8 TC: 2 TC for each behaviour
- Advice on how to convert all ToyBox aims into practice



→ Aim: transfer key messages, motivate parents and get them actively involved

OUTCOMES – baseline and end of intervention

- Children's Physical Activity: Pedometers
- Anthropometry



- Worn all day
- 6 consecutive days (incl. 2 weekend days)

- Diet: Modified Child's Food Frequency Q're with Food Portion Size Photos
- CORE-Q: Parents attitudes, beliefs, behaviours related to target behaviours

2010 | 2011 | May/June 2012 | May/June 2013 | 2013 | 2014

ToyBox Study Publications

Over 50 Publications to date, since 2012…

Categories of the papers:

- Background, planning, design, methods, cross-sectional and longitudinal findings (including descriptive/predictive models), and intervention outcomes (including sub-samples) vs. Controls.
- More under review and in preparation…

Summary of 7 intervention outcome papers (all countries)

Authors	N	Summary of key outcomes
Miguel-Berges et al (2019)	4836	Intervention maintained % children adhering to screen-time guidelines vs control. Predicted by parental rule setting.
Lambrinou, van Stralen *et al* (2019)	5212	Intervention improved parental strategies around child snacking, but not snacking itself.
Lambrinou, van Stralen *et al* (2018)	3725	Water consumption improved by intervention vs control, strongly mediated by parental water-drinking attitudes and behaviours.
De Craemer, Verloigne *et al* (2017)	2438	No sig intervention effects on steps/d overall or by country, but better effects where KG teachers' process evaluations were higher.
Pinket, De Craemer, Huybrechts *et al* (2017)	4968	Subcomponents of total diet quality (TDQ), i.e. 'dietary quality' and 'dietary equilibrium' were improved by the intervention, but not TDQ.
Latomme *et al* (2017)	2434	Intervention effects on sedentary behaviours: computer/video game use increased less after I vs C, esp. in Belgium & Bulgaria. For parents, not teachers, process evaluation was predictive.
Pinket AS, Van Lippevelde *et al* (2016)	4964	Small intervention benefits to water intake, but clear reduction for packaged FJ, but also milk. Better beverage effects where parents and teachers have higher implementation scores.

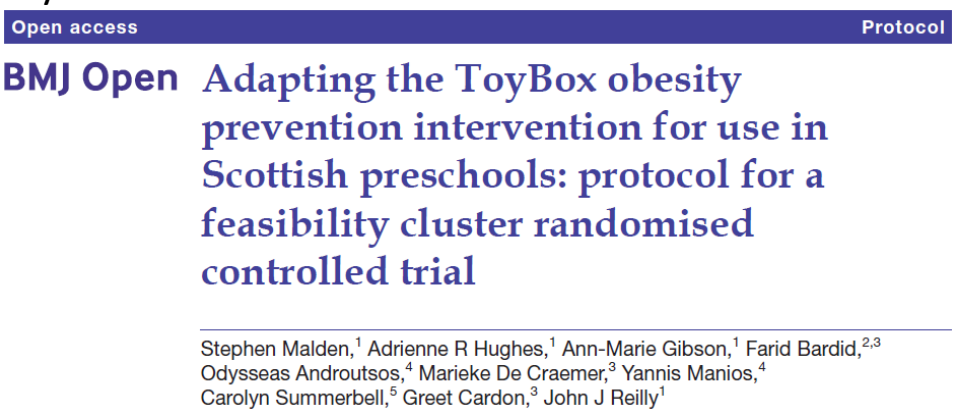
Summary of 3 subsample intervention outcome papers

Authors	N	Summary of key outcomes
Birnbaum *et al* (2017)	Germany: 1293	German subsample: Intervention improved motor performance (e.g. jumping) though most reliably in older boys.
De Craemer, De Decker *et al* (2016)	Belgium: 859 kids, 1715 parents	Belgium subsample: No overall intervention effects on sedentary behave (SB), but higher SES and higher baseline SB showed less SB while controls increased SB. Intervention decr TV time in girls.
De Craemer, De Decker *et al* (2014)	Belgium: 472	Belgium only: Small intervention increase in PA but more reliable in subgroups esp higher SES boys. Control either no change or decrease PA.

ToyBox Going Global

→ 'ToyBox Study Malaysia': MRC/Newton-Ungku Omar funded 2-yr feasibility study in Peninsular Malaysia (UKM) and Sarawak (UNIMAS; NW. Borneo): ~1000 children and parents over the 2 regions (http://toybox-study.my/)

→ 'ToyBox Scotland':

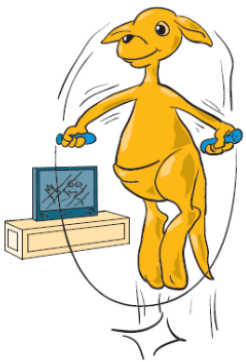


→ Additional interest/take up from many other countries: Argentina, Ecuador, Estonia, Italy, Malta, New Zealand, Nicaragua, South Africa…

Summary and Conclusions

- → Intervention resulted in some modest improvements in energy-balance related behaviours, esp. where well implemented.
- → Probably little evidence for a reduction in adiposity. Are preschool children too young for impact on adiposity?
- → ToyBox-Study included as example of good practice in JA-CHRODIS report.
- → Multidisciplinary team is required for developing a large intervention.
- → Flexibility is needed to make the intervention feasible and deliverable in all participant countries.
- → Kindergarten environment has 'pros' and 'cons' but at least children can learn good habits from a young age.
- → Role of parents particularly important for this age group – more could have been done to engage them…
- → No measure of picky/fussy eating.
- → Confound on some odd findings, e.g. heavier children drink more water? Faster growing children may have higher BMI/weight but also higher energy/nutrient needs and thus higher fluid intake… Adjust for energy needs?

EU ToyBox-Study Group



www.toybox-study.eu

ToyBox Study Malaysia Team

http://toybox-study.my/