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Cognitive function measurement in online self-completion surveys

Dr Cristian Domarchi (University of Southampton) – *Presenting Author*
Professor Olga Maslovskaya (University of Southampton)
Professor Lisa Calderwood (Centre for Longitudinal Studies, University College London)
Mr Matt Brown (Centre for Longitudinal Studies, University College London)

Online Workshop – 26th November 2026

Survey Futures

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- **Survey Futures** is a research programme focused on ensuring large scale surveys in the UK can innovate and adapt in a changing environment.
- Survey Futures is funded by the UK's Economic and Social Research Council (ESRC).
- The programme is a collaboration between nine universities, and three survey agencies (NatCen, Ipsos, and Verian), in partnership with the National Centre for Research Methods (NCRM), and the Office for National Statistics (ONS).
- The programme includes over 50 researchers working across nine research strands, covering the most significant topics of survey research.
- Visit our website: https://surveyfutures.net/

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Research Strand 5

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- **Research Strand 5** of Survey Futures studies **complex measurements in online self-completion surveys**.
- Accurately capturing complex phenomena is critical for the success of social surveys.
- As the field increasingly shifts towards online data collection, a key challenge emerges: how to administer complex measures without compromising data quality or comparability with other survey modes.
- Four types of measurements:
  - Industry and occupation coding.
  - **Cognitive assessments.**
  - Consent to data linkage.
  - Event histories and retrospective data.

Cognitive measures

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- Cognitive function is a key determinant of health, economic, educational, and social outcomes across the life course.
- Incorporating measures of cognition into large-scale surveys enables researchers to track population trends, detect early signs of decline, and evaluate potential interventions.
- However, administering these measures in online surveys is challenging: many instruments are designed for in-person administration, and there is strong evidence of mode effects when they are adapted for online self-administration.

Cognitive measures

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- Survey Futures published an **evidence review** on **cognitive function measurement in online self-completion surveys**.
- We focus on reviewing large-scale surveys that have implemented cognitive measures for different population groups, including:
  - Surveys for the ageing population
  - Surveys of children and young people
  - General population surveys
- We review academic papers, conference presentations, survey technical reports, and other published literature.

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Cognitive measures

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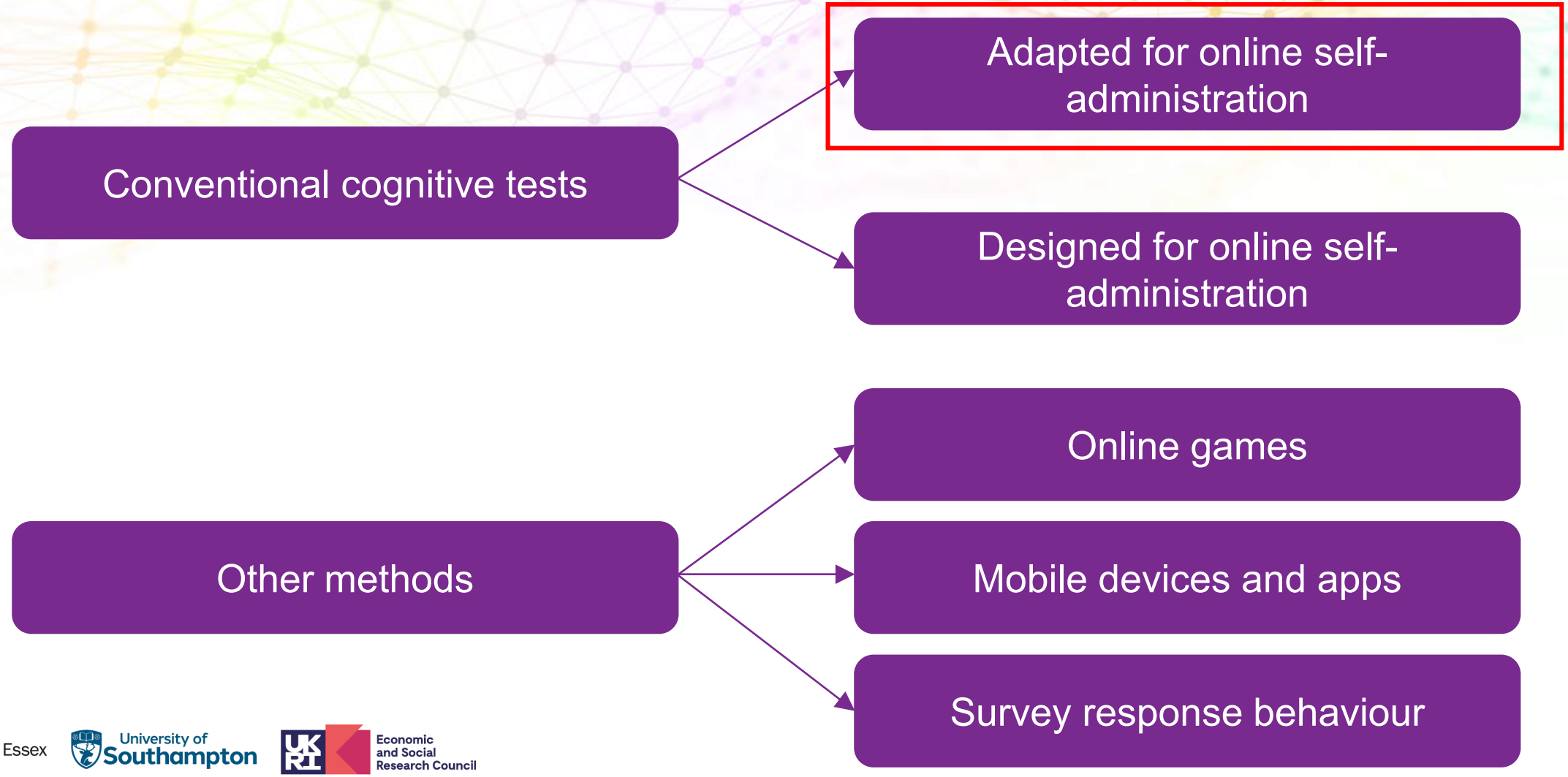
- The evidence review describes the issues related to cognitive data collection, including:
  - Identifying the surveys that have used web-based cognitive ability measures
  - Describing the cognitive questionnaires, test batteries (i.e. sets of cognitive tasks), and other methods of data collection
  - Characterising the data quality challenges associated with cognitive data collection
  - Providing recommendations and best practice guidance for measuring cognitive ability in online self-administered surveys

Methods overview



Measures adapted for online self-administration

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- Long-running longitudinal surveys have historically collected cognitive data through interviewer-administered modes (in-person and via telephone).
- Tests are usually derived from validated tools and cover domains such as:
  - **Memory**: Immediate word recall, Delayed word recall
  - **Attention and concentration**: Backwards count, Serial 7s
  - **Orientation and language**: Date naming, Object naming, President naming
  - **Vocabulary and numeracy**: Defining words, Arithmetical problems
  - **Fluid intelligence:** Animal naming, Verbal analogies, Number series

Measures adapted for online self-administration

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- When administering these tests online, experiments conducted in the **Health and Retirement Study (HRS)** find significant **mode effects:**
  - Ofstedal et al. (2021), comparing in-person/telephone 2012 with web 2013, and in-person/telephone 2014:
    - Respondents generally scored higher in web-based assessments compared to interviewer-administered tests
    - Mode also influenced psychometric properties (reliability/validity) of the tests
  - Domingue et al. (2023), comparing in-person 2016 with telephone/web 2018:
    - Respondents generally scored higher in web-based assessments compared to both telephone and in-person

Measures adapted for online self-administration

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- Experiments conducted in the **Understanding Society Innovation Panel** found similar results:
  - Al-Bhagal (2019), compared self-administered and in-person tests in Wave 7:
    - Respondents generally scored higher in web-based assessments compared to interviewer-administered tests across all measures
    - The differences persisted even after controlling for sociodemographic variables

Measures adapted for online self-administration

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- **Possible sources of mode effects**:

In-person administration:

- Interviewers can ensure continued engagement with the survey and provide instructions and clarification
- However, their presence may also introduce pressure to perform

Online self-administration:

- Respondents can use external aids (e.g. calculators, search engines, assistance from others), distorting scores.
- The absence of an interviewer may reduce engagement, leading to careless responding
- However, it may also reduce performance pressures

Measures adapted for online self-administration

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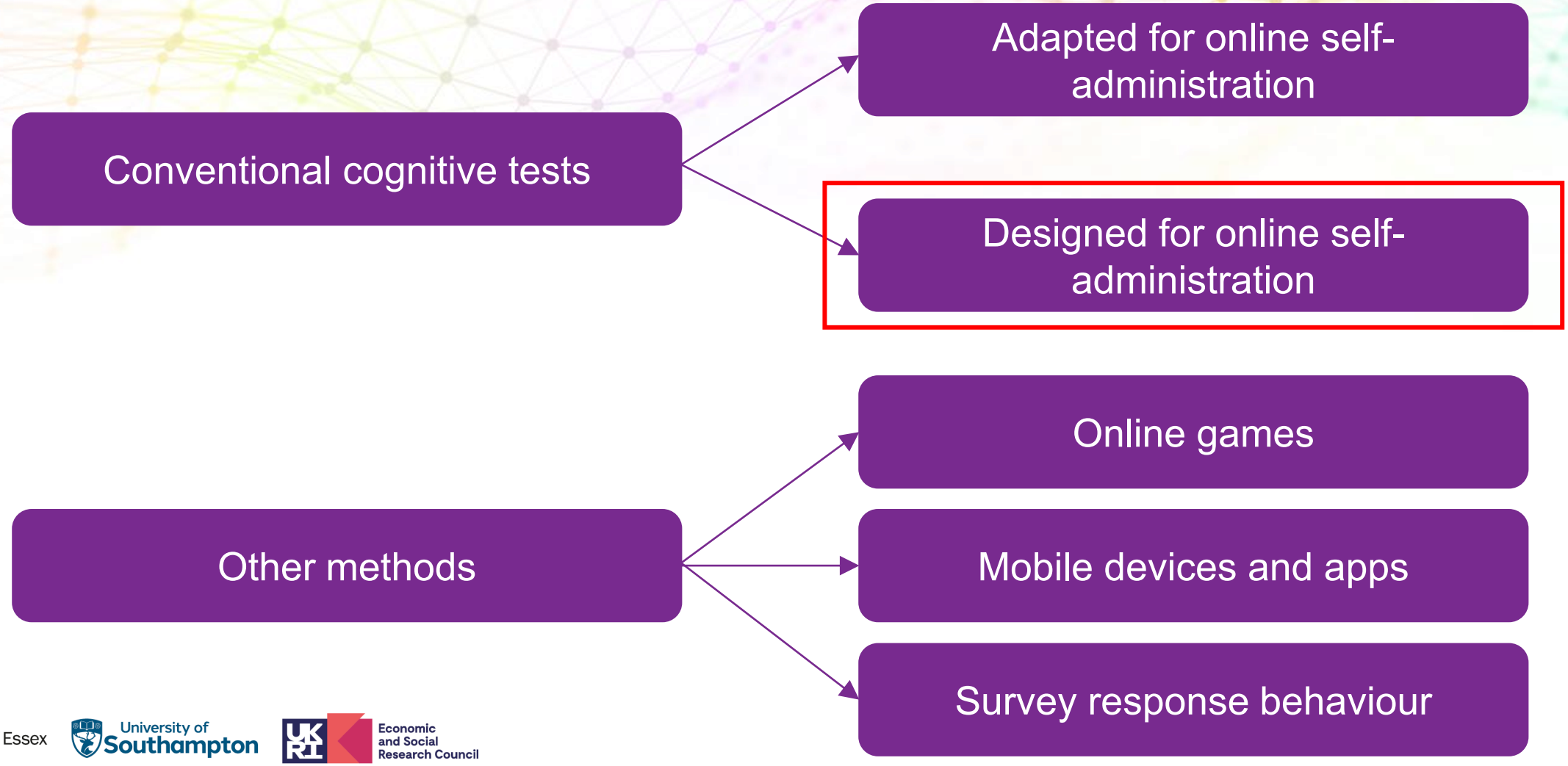
- **Pros**:
  - Maintains longitudinal consistency with in-person tests from previous survey waves.
  - Self-administration reduces the potential for interviewer-led biases.
  - Benefits from well-established psychological validity and reliability.
- **Cons**:
  - Strong evidence of mode effects, particularly for respondents with lower cognitive ability.
  - Unsupervised administration can compromise data quality.
  - Device type, screen size, and internet speed can influence performance, introducing new biases.

Methods overview



Measures designed for online self-administration

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- More recently, longitudinal surveys have been using cognitive tests specifically designed for remote self-administration.
- Widely validated test batteries used in large-scale social surveys include:
  - **Cognitron** (National Survey of Health and Development NSHD, UK; REACT study, UK)
  - **Cogstate** (Raine Study, Australia)
  - **TestMyBrain** (Twins Early Development Study TEDS, Next Steps, Millennium Cohort Survey, UK)
  - **UK Biobank** (UK Biobank study)

Measures designed for online self-administration

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- **Cognitron:**
  - Online platform that hosts over 100 optimised cognitive tasks, designed to be "sensitive, domain-specific, and validated across both general and clinical populations" (Hampshire et al., 2024)
  - Domains include:
    - **Working memory**: Object immediate and delayed recall
    - **Language**: Word definition, Verbal reasoning
    - **Processing speed**: Motor control, Choice reaction time, Spotter, Forager
    - **Visuospatial abilities**: Blocks, Spatial span, 2-D manipulation
    - **Executive function**: Digit span, Stroop

Measures designed for online self-administration

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- **Cognitron:**
  - In 2023, NSHD invited participants with internet access and an email address to complete cognitive tests using Cognitron (Cai *et al.*, 2024)
  - Participants could access the tasks through a web browser on any smartphone, tablet, or PC/laptop computer
  - 1,753 members of the NSHD cohort (all aged 77) were invited to participate:
    - 990 (56.4%) provided consent
    - 813 (46.4%) attempted the battery
    - 88.8% of the ones who began the test completed all 13 tasks
    - The median completion time was 41 minutes
  - Consent, participation, and completion rates were positively linked to sociodemographic and health-related factors

Measures designed for online self-administration

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- **Cogstate:**
  - Widely used computerised cognitive test battery, designed to be repeatable, sensitive, and efficient, with a culturally neutral and language insensitive format (Allen et al., 2012)
  - Domains include:
    - **Working memory**: Continuous paired associate learning test, One card learning test
    - **Attention/Concentration**: Identification test
    - **Processing speed**: Detection test
    - **Executive function**: Groton Maze Learning Test, Set shifting test

Measures designed for online self-administration

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- **Cogstate:**
  - Although originally developed for self-administered use in computers, studies have supported the validity of CogState assessments in other devices, including tablets, iPads and mobile phones
  - Mielke et al. (2015): participants were faster and more accurate using a keyboard or mouse on a PC compared to finger touch on an iPad, though they preferred the iPad and *believed* they performed better on it
  - Cummins *et al.* (2025): participants were faster on computers compared to smartphones. While over 85% of participants found text and button size appropriate in smartphones, there was no strong preference for either device
  - Issues like fatigue, distraction, and input method challenges were noted for all devices

Measures designed for online self-administration

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- **TestMyBrain:**
  - Hosted on the TestMyBrain.org platform
  - The tests have been widely validated, demonstrating high validity and consistency with tests taken in lab or clinical settings (Singh et al., 2021)
  - Domains include:
    - **Vocabulary**: Vocabulary test
    - **Processing speed**: Symbol matching test
    - **Memory**: Verbal paired associates memory test
    - **Executive function**: Forwards and backward digit span test, Stroop test

Measures designed for online self-administration

SURVEY FUTURES
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- **TestMyBrain:**
  - **Millennium Cohort Study (MCS) Age 23 and Next Steps Age 32 Surveys:**
    - Both mixed mode surveys including online and in-person administration
    - Both used the backward digit span (BDS) test. MCS Age 23 also used the Stroop test
    - The tests were administered as part of the web survey for online participants
    - For in-person participants, the same tests were completed via self-completion on the interviewer's tablet. Interfaces were identical in both modes
  - **Methodological study by the Centre for Longitudinal Studies (CLS)**:
    - A convenience sample of 1,800 participants aged 20–40 living in England was recruited
    - Participants were asked to complete two surveys (both of which included the BDS), two weeks apart
    - Participants were allocated to web, video, or in-person modes at both time points, creating nine mode sequences. The BDS was completed via self-completion in all modes
    - Encouragingly, early findings show that mode effects are minimal (Tsigaridis *et al.*, 2025)

Measures designed for online self-administration

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- **TestMyBrain:**
  - Passell *et al.* (2021) analysed cognitive test scores from about 60,000 participants (2014–2019)
  - They found that users of mobile devices (particularly those on Android smartphones) performed significantly slower on tests of reaction time than laptop and desktop users
  - These differences remained significant even after controlling for sociodemographic characteristics and may be related to aspects such as device latency, operation system, input type (touchscreen vs mouse), and screen size

Measures designed for online self-administration

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- **UK Biobank:**
  - Large prospective cohort study investigating the health of middle-aged and older adults in the UK, with around 500,000 volunteers aged 40–69 were recruited (non-probabilistic sample) (Fawns-Ritchie and Deary, 2020)
  - Cognitive tests are completed unsupervised via a fully automated touchscreen interface in a lab setting
  - Domains include:
    - **Memory**: Pairs matching test, Prospective memory test, Numeric memory test, Paired associate learning test
    - **Verbal/numerical reasoning**: Fluid intelligence test
    - **Executive function**: Trail making test, Tower rearranging test. Matrix pattern completion
    - **Processing speed**: Symbol digit substitution
    - **Crystallised ability**: Picture vocabulary

Measures designed for online self-administration

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- **UK Biobank:**
  - Tests overlap with other online assessments, and with tests from the HRS
  - Fawns-Ritchie and Deary (2020) found strong concurrent validity between the UK Biobank cognitive battery and established standard tests of cognitive ability. However, there are some variations across tests and domains

Measures designed for online self-administration

SURVEY FUTURES
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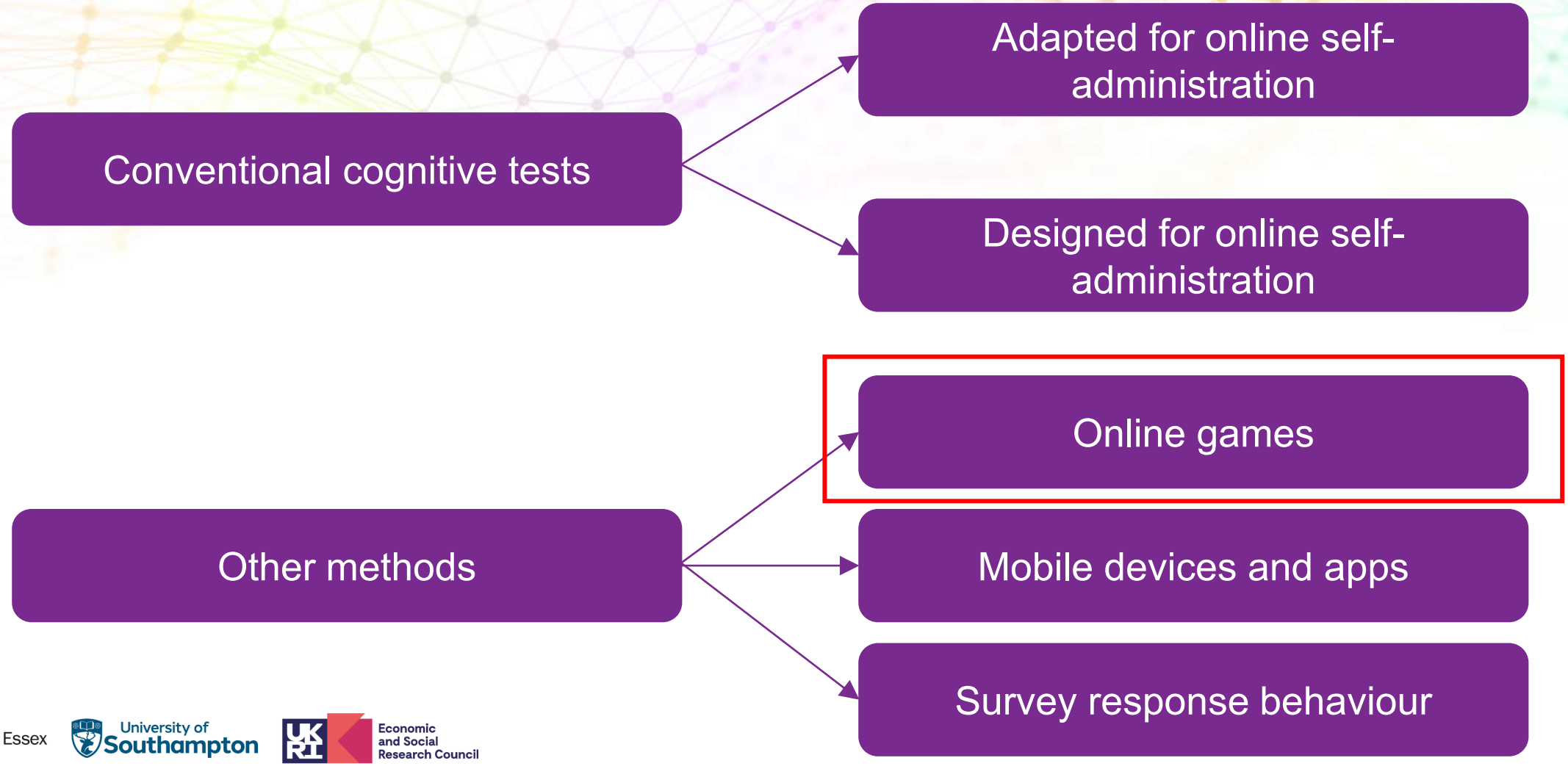
- **Pros**:
  - Removes potential interviewer-led biases
  - Built on a foundation of well-established validity and reliability
  - Helps minimise mode effects
- **Cons**:
  - Unsupervised administration can compromise data quality
  - Device type, screen size, and internet speed can influence performance, introducing new biases

Methods overview



Online games

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- Cognitive ability has been assessed with games using two primary approaches:
  - Specially designed games created to boost engagement
  - Conventional cognitive tests embedded within a gamified environment

Online games

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Sea Hero Quest:

- A smartphone and tablet-based video game that assesses wayfinding and path integration.
- Players navigate a boat from a starting point to various destinations on a map.
- Implemented in Wave 16 of Understanding Society's Innovation Panel.
- 47.3% of invited participants downloaded and started using the app.
- Game completion rates vary according to incentives offered (between 47.4% and 57.4% of those who started the game) (Coutrot *et al.*, 2024).

Source: http://bbc.com/news/technology-36203674

Online games

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Pathfinder:

- A gamified assessment that embeds five cognitive tests within an engaging storyline
- Cognitive tests include visual puzzles, matrix reasoning, verbal analogies, vocabulary, and missing letters
- Implemented in a sample of 4,751 21-year-old twins from TEDS (2014-2016)
- Measures derived from Pathfinder demonstrated reliable verbal and non-verbal scores, which correlated substantially with standard cognitive measures collected at earlier stages of TEDS (Malanchini *et al.*, 2021)

Source: https://www.youtube.com/watch?v=KTk1Ej4F8zE

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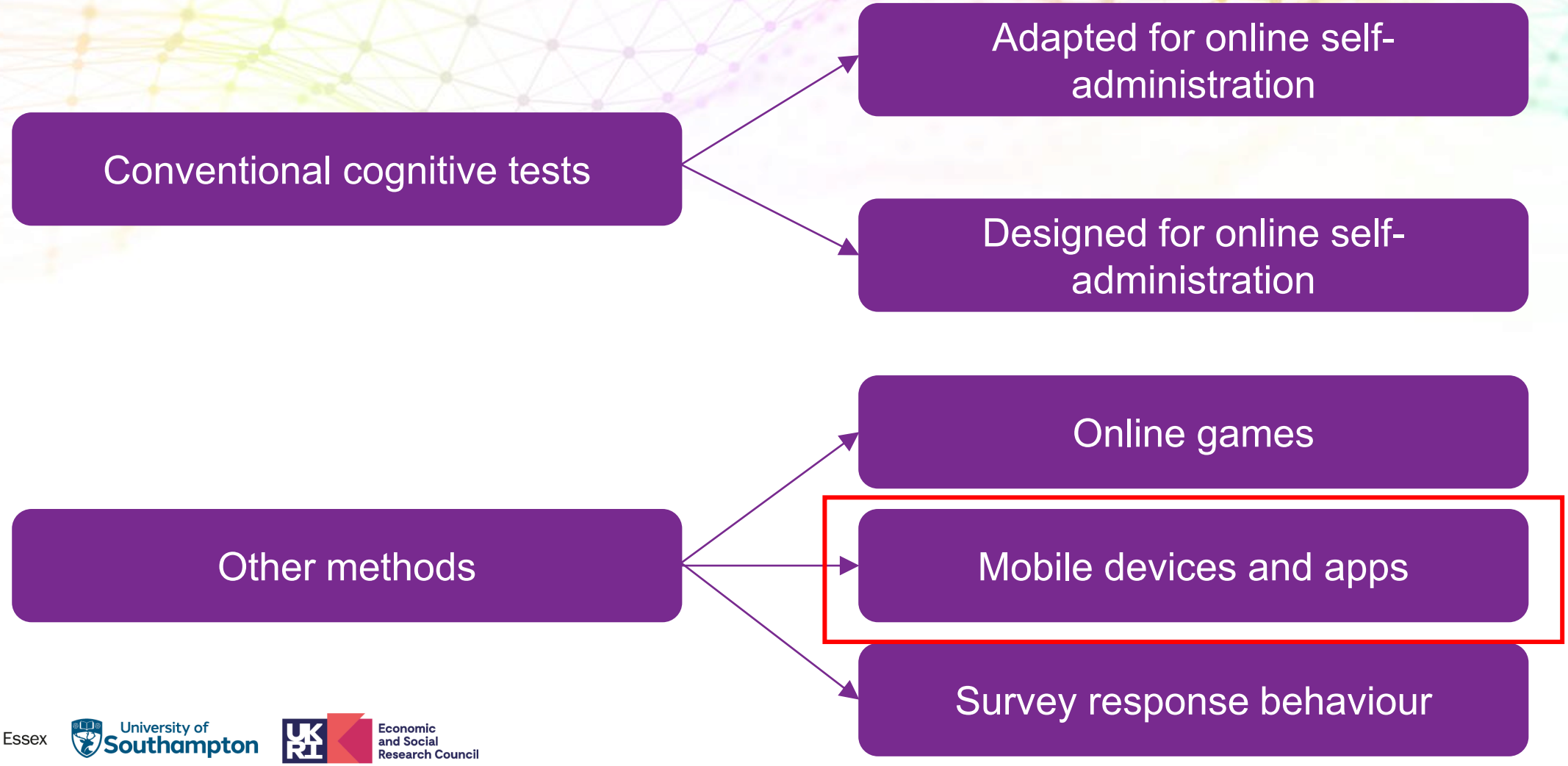
Online games

- **Pros**:
  - Increases participant engagement and reduces attrition
  - Can provide a more authentic measure than static tests by simulating real-world dynamic environments
  - Generates rich, process-oriented data beyond simple performance scores

- **Cons**:
  - Game performance can be influenced by factors confounded with cognitive ability, such as:
    - Participant motivation
    - Familiarity with game mechanics
    - Device type and connectivity
    - General aptitude for digital games
  - Design and implementation can be costly
  - Reliability and validity of game performance as a proxy for cognitive ability are not yet well-established

Methods overview



Mobile devices and apps

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- Cognitive measures can be collected from mobile devices, wearables, and apps, due to the widespread use of smartphones and other devices with high storage capacity and connectivity (including among the ageing population)
- Smartphone-based cognitive assessments include:
  - Mobile versions of existing tests
  - New tests for mobile devices, usually implemented as brief, frequent, and repeated assessments

Mobile devices and apps

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- Other data types collected via smartphones, sensors and other devices, including:
  - **Speech analysis apps**: Analysis of vocal characteristics has been used to detect irregularities in human speech and language (Al-Hammadi *et al.,* 2024)
  - **Physical movement analysis**: Fine motor skills measurements derived from tapping on a tablet screen have been used to detect irregularities in finger dexterity (Suzumura *et al.*, 2018)
  - **GPS data**: Distance covered has been used to measure cognition, as smaller distances have been associated with cognitive decline (Cullen *et al.*, 2021)
  - **Activity daily-life performance**: Performance in virtual reality environments has been used to analyse cognitive function. These include including virtual supermarkets or automated teller machines, face recognition, pillbox management, collected via sensors or wearables (Veneziani *et al.,* 2024)

Mobile devices and apps

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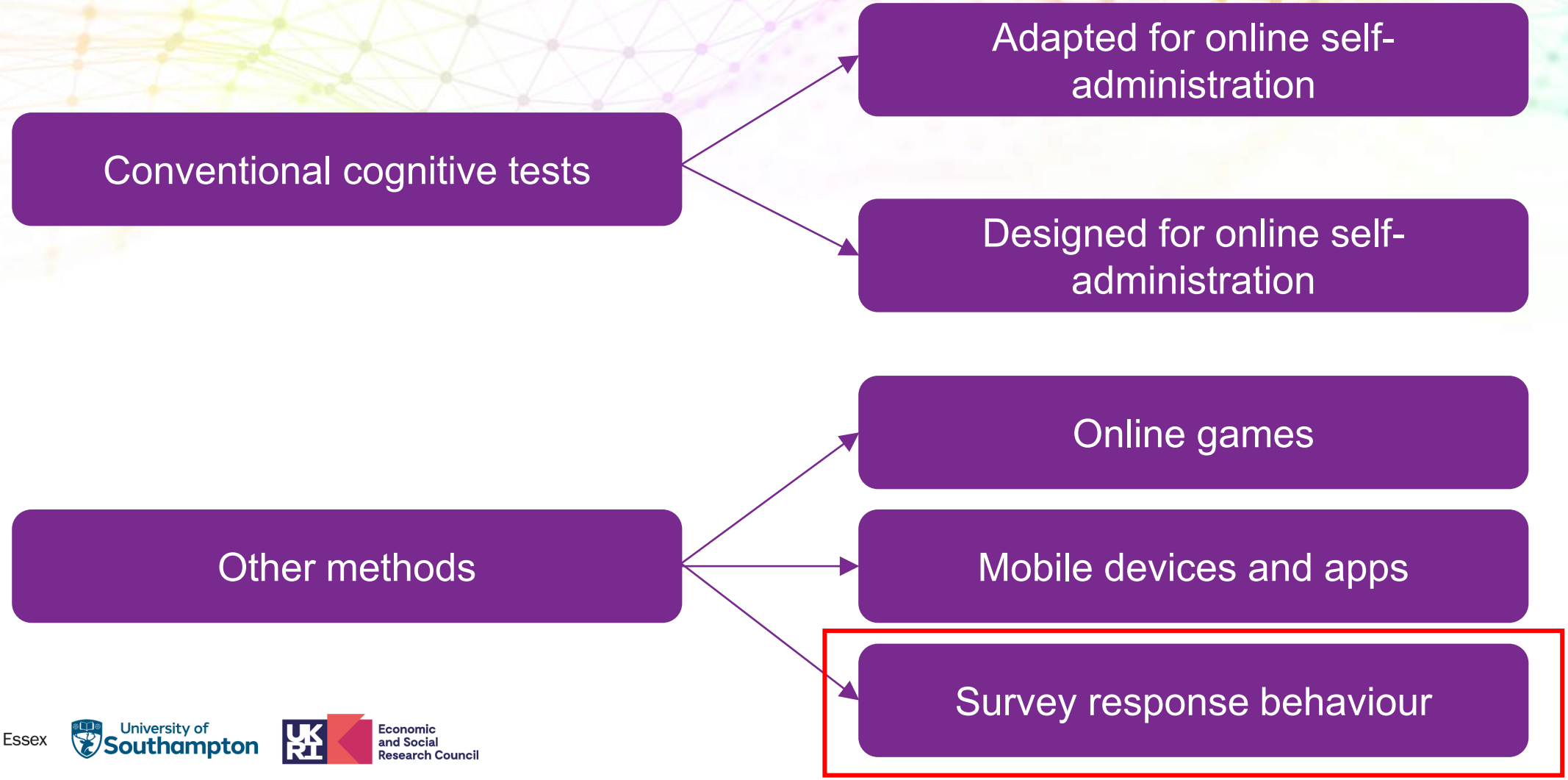
- **Pros**:
  - Non-intrusive and requires minimal user effort
  - Collects large volumes of high-frequency data
  - Increases participant engagement and improves accessibility
  - Reduces or eliminates interviewer effects

- **Cons**:
  - Performance can be influenced by factors confounded with cognitive ability, including:
    - Contextual and environmental conditions
    - User's physical state
    - Device type and connectivity
  - Risk of attrition and missing data due to battery consumption, privacy concerns, and the need to carry the device
  - Reliability and validity of these indicators as proxies for cognitive ability are not yet well-established

Methods overview



Survey response behaviour

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- Survey response (a cognitively complex activity) provides a means for inferring cognitive ability.
- Two types of indicators have been studied:
  - **Response quality indicators**, including item non-response and uncertainty, response styles, and response consistency
  - **Survey paradata indicators**, including time from invitation to response, completion time, errors and corrective behaviour, keystrokes, mouse and touch efficiency
- Low performance across these indicators has been linked to cognitive decline.

Survey response behaviour

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- Ongoing research studying the link between low response quality indicators and cognitive decline:
  - Jin et al. (2023) and Schneider et al. (2024) find a strong association using data from ELSA, HRS, SHARE, and TILDA surveys
  - Junghaenel *et al.* (2023) find a weak correlation using seven years of Understanding America data. However, a stronger association appears over lag periods ranging from one to at least six years
  - Gao et al. (2024) find that a machine learning algorithm based on survey response quality data to predict the incidence of dementia and mortality in the HRS sample, outperforms an algorithm based on age and health-based screening strategies

Survey response behaviour

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- **Pros**:
  - Non-intrusive and cost-effective
  - Provides direct observation of a complex, real-world cognitive task
  - Paradata are often readily available in existing surveys
  - Can assess multiple cognitive domains simultaneously

- **Cons**:
  - Response behaviour can be influenced by factors confounded with cognitive ability, such as:
    - Participant motivation and engagement
    - Social desirability bias and survey fatigue
    - Device type, connectivity, and questionnaire design
  - Reliability and validity of these indicators as proxies for cognitive ability are not yet well-established

Summary

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- Several large-scale surveys (predominately longitudinal) have successfully implemented self-administered online cognitive tests for respondents of all age groups.
- Significant mode effects are sometimes found when cognitive assessments are administered using different modes (e.g. in-person versus online self-administration).
- These effects are particularly pronounced when tests originally designed for interviewer administration are adapted for online use, and they are greater among respondents with lower cognitive functioning.
- Innovative measures (e.g. games, apps, survey response behaviour) are a promising alternative, but further research is required.

Key recommendations

- Select tests designed for online self-administration and adapt them for other modes, rather than adapting interviewer-led “gold standard” measures for self-completion.

- Those participating in-person should complete assessments via self-completion, although even the presence of an interviewer can still have an impact on performance.

Practical recommendations for mixed-mode surveys

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- Choose tasks with short, simple responses, as they are less sensitive to mode and device effects than more complex tasks that depend heavily on a specific administration format
- Ensure instructions, scripts, language, and time limits are consistent across all modes to minimise variability in test administration
- Encourage participants to complete the assessment in a quiet space to reduce distractions and improve focus
- Remind participants that honest answers are vital and that a perfect score is not expected, which can help reduce the incentive to cheat (Lachman and Alwin, 2008)

Considerations for selecting an online cognitive assessment

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- **Age group:** Assessments must be age-appropriate. Tests for children are shorter and less complex, while those for older adults often accommodate declines in processing speed, memory, and sensory abilities
- **Scientific validity and reliability:** Tests should be independently validated, ensuring they are reliable, valid, and sensitive enough to detect subtle differences in the target cognitive domain
- **Practical feasibility:** User-friendly interfaces with clear instructions are essential for achieving high completion rates, especially among less technically literate populations

Considerations for selecting an online cognitive assessment

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- **Implementation costs:** Budget for significant expenses, whether from licensing established batteries (e.g., Cognitron, Cogstate) or developing new data collection methods
- **User testing:** Piloting tests with the target population ensures the battery is accessible and functions correctly across various devices
- **Data confidentiality:** Participants must be provided with clear information on how their data will be used, stored, and protected

Further research

- Suggested topics for further research:
  - Causes of mode effects and strategies for mitigation
  - Statistical treatment of time series of cognitive data collected in different modes
  - Device effects and their treatment
  - Reliability and validity of non-conventional approaches
- Experimental research is essential.

Survey practice guide

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- A survey practice guide on cognitive assessments for online surveys will be published **soon** on the Survey Futures website.
- For each method, it will discuss:
  - Advantages and limitations
  - Wider considerations for their implementation
  - Practical recommendations

Discussion

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- Experiences of cognitive function data collection in online surveys.
- Takeaways and challenges.
- Recommendations for survey practice.
- Suggestions for further research.

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