UNRAVELLING FUTURE THINKING: A VALUABLE CONCEPT FOR PROSPECTIVE ERGONOMICS

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This is a manuscript of an article published by Taylor & Francis in THEORETICAL ISSUES IN ERGONOMICS SCIENCE on 05/07/2021. The final version is available at doi.org/10.1080/1463922X.2021.1943045.

Abstract: Future thinking (FT) is the cognitive ability that enables humans to mentally imagine and pre-experience future events. Despite a sharp increase in basic research on future thinking in the last decade, we note the lack of transfer to Human Factors and Ergonomics (HF&E), although the field is increasingly concerned by future artefacts and although theory building on future-oriented HF&E has begun (e.g., prospective ergonomics). This article gives an overview of key findings regarding future thinking, namely i) underlying cognitive mechanisms, ii) functions and obstacles, iii) common descriptors of future thinking, iv) recommendations as to the possible improvement of future thinking during user research and, v) methods for the assessment of future thinking abilities. This synthesis can support HF&E practitioners in fine-tuning their future-oriented methods.

Keywords: prospective ergonomics, future thinking, mental time travel, future-oriented cognition, needs anticipation

1/Introduction

Faced with growing uncertainties regarding the future, public and private organisations are turning to foresight-oriented design practices in order to probe alternative futures and future users' needs. Needfinding (Faste 1987), design fiction (Sterling 2005), future literacies (Miller 2007, 2018), speculative design (Dunne and Raby 2013), and prospective ergonomics (Laurig 1984; Robert and Brangier 2009) are some of the user-centred frameworks that have been developed in order to do so. Early on, HF&E has been concerned with getting in as early stage as possible in the invention process (Bartlett 1962). However, research within HF&E was still qualified as '*reactive*' (vs. '*anticipatory*') in 1980 (De Greene 1980). In the mid-1980's future-oriented (or '*prospective*') ergonomics was formalized (Laurig 1984, 1986, 1992; Laurig and Vedder 1998) and has been further theorized in the 2010's (e.g., Robert and Brangier 2009, 2012; Brangier and Robert 2014; Barre 2015; Robert and Brangier 2019; Nelson 2019; Loup-Escande 2019). Prospective ergonomics has been distinguished from '*corrective*' and '*preventive*' ergonomics (as identified by de Montmollin 1967; see Table 1 below). It is defined as '*an ergonomic approach which consists in anticipating future needs, usages and behaviours, or to develop future needs in view of creating processes, products or services well adapted to them*' (Brangier and Robert 2014). Beyond research labelled by the authors themselves as '*prospective ergonomics*', future-oriented theory building (e.g., the concept of probable and desirable future activities discussed by Sagot, Gouin, and Gomes 2003; Daniellou 2004; Duarte and Lima 2012) as well as research on future artefacts (e.g., Schmorrow and Schatz 2016; Navarro 2019; Bonnardot et al. 2020) is common within our field.

Table 1: Modes of ergonomic interventions (adapted from Brangier and Robert 2014).

Intervention modality / Characteristics	**Prospective**	**Preventive**	**Corrective**
Actions and goals	Anticipate future needs and activities and imagine ideas of corresponding artefacts	Improve the design or development of a proven artefact	Adjust an artefact to the problems encountered by its users
Dynamics	Proactive	Proactive/ Reactive	Reactive
Temporality of reference	Future	Present	Past

Yet, one question remains unexplored by these researchers: what is the underlying cognitive process enabling humans to imagine the future? Indeed future-oriented research is often based on some form of user research requiring '*future thinking*' (hereafter FT) from users or designers (Dong, Collier-Baker, and Suddendorf 2017). New methods supporting FT are rare (two exceptions are the Guided Imaginary Projection by Allinc, Cahour, & Burkhardt, 2019, and Setting the Stage by Pettersson & Karlsson, 2015) and clarifications as to the theoretical roots of FT have not been circulated even within the larger design community.

FT is a process that could be integrated into prospective approaches through structured methods. This would enable users and HF&E practitioners to more easily enrich their future representations, anticipate future needs, define future usage contexts, imagine future artefacts and the activities they may generate. Thus, the goal of this review is to summarize basic research on FT in order to contribute to theory building in our field. FT theory can, in turn, support HF&E practitioners interested in developing a common language as well as fine-tuning and adding rationale to current and new future-oriented research methods. There is indeed a necessity for rationale practices whose use should be understood and explainable by designers as highlighted by Carroll (2013, 1–2). In any case, the application of FT insights to practice is still in its infancy. Nevertheless, it seems a relevant and promising concept for discussion and application.

Originally, future thinking was described as a self-centred ability and defined as the '*mental simulation of future events or circumstances that one might be personally involved in*' (Atance & O'Neill, 2001 cited by Hallford & D'Argembeau, 2020). More recently, researchers have emphasized that FT events take place within a continuum ranging from pure episodic (personal, specific) simulations to pure semantic (general) simulations (Szpunar, Spreng & Schacter, 2014). Building on the above, we define

FT as '*the ability that allows the mental simulation and/or pre-experience of future events of personal, general and hybrid nature*'.

Other terms have been used to name FT, such as '*prospection*' (Buckner and Carroll 2007; Gilbert and Wilson 2007; Seligman et al. 2013), '*anticipation*' (Sutter 1990; Riegler 2001; Zamenopoulos and Alexiou 2007), '*future-oriented cognition*' (D'Argembeau, Renaud, and Van der Linden 2011), '*future-oriented mental time travel*' (Michaelian, Klein, and Szpunar 2016) etc. In this review '*future thinking*' has been chosen for its simplicity and evocative power. '*Future-oriented mental time travel*' (FMTT) would be the more convoluted but precise alternative. It is of note that future thinking is indeed part of a higher-order ability that allows for both past- and future-oriented thinking termed '*mental time travel*'.

This review is divided into five sections, each relating to topics that can help HF&E practitioners better understand or include FT in user research. They tackle the following research questions (RQ):

(1) RQ1: What research has been done previously on the topic of FT within HF&E?
(2) RQ2: What are the neuro-cognitive bases of FT?
(3) RQ3: What are the underlying functions of FT?
(4) RQ4: What are the obstacles to FT?
(5) RQ5: How can HF&E researchers and practitioners describe and measure FT events?
(6) RQ6: What are possible recommendations as to the improvement of FT abilities?
(7) RQ7: How can researchers and practitioners prime/cue FT in their protocols?
(8) RQ8: How to assess FT abilities?

2/ Theoretical framework

2.1/ Previous approach of FT within HF&E

In order to map previous work on future thinking within HF&E, we surveyed 9 journals and proceedings whose titles explicitly referred to '*human factors*' or '*ergonomics*' in the 'Human Factors and Ergonomics' section of the SCImago database (i.e., Human Factors, Applied Ergonomics, Ergonomics, International Journal of Industrial Ergonomics, Theoretical Issues in Ergonomics Science, Human Factors and Ergonomics In Manufacturing, Ergonomics in Design, International Journal of Human Factors and Ergonomics, Proceedings of the Human Factors and Ergonomics Society). Using the Web of Science search engine, we targeted publications whose topic (abstract, title, keywords) contained a reference to '*prospective*', '*prospection*', '*anticipation*', '*future thinking*', '*future-oriented cognition*' or '*mental time travel*'.

The search yielded 221 results. None of the results contained a reference to either '*future thinking*', '*future-oriented cognition*' or '*mental time travel*'. Of the 221 results,

165 publications were excluded since they used the terms '*prospective*' or '*anticipation*' in meanings unrelated to cognition about the future (e.g., '*prospective users*', '*prospective studies*'). The remaining 56 publications can be classified into 3 categories: specific anticipation (N=37), prospective memory (N=14), and general anticipation (N=5). The 37 '*specific anticipation*' publications deal mostly with short-term anticipation of risks, errors, actions, loads (e.g., anticipation as requiring a cognitive effort in aviation, see Suhir et al. 2015). Here, '*anticipation*' is seen as an HF&E variable that is measured but not theorized. The 14 '*prospective memory*' publications deal with a more delimited and stable concept, prospective memory, that can be defined as '*occasions when intent has been formed and stored in working memory for later recall*' (Saward and Stanton 2015). This second category exemplifies again the short-term view of future thinking within HF&E, which is symptomatic of corrective ergonomics. Finally, the 5 publications we grouped under the '*general anticipation*' label are more diverse and more akin to future thinking as defined in this paper. Two of them briefly mention prospective activities and prospective diagnoses without further theorization but nevertheless consider more complex activities and a less immediate future (Rosen et al. 2010; Wiggins 2014). The three others (Nelson, Buisine, and Aoussat 2013; Bonnardel and Didier 2020; Loup-Escande and Loup 2020) are affiliated with '*prospective ergonomics*' by the researchers themselves and target respectively anticipation of future use, brainstorming techniques and anticipation of future needs. Bonnardel and Didier's study (2020) is concerned with increasing creativity. However, the theoretical roots of the two variants of the brainstorming technique they present are those of creativity, which is already well discussed within human-centred fields and not directly related to FT theories. Loup-Escande and Loup's article (2020) is concerned with the acceptance of new technology but does not tackle future thinking. Nelson, Buisine and Aoussat's work (2013) tackles in part future thinking by reporting '*findings in cognitive psychology regarding biases in the anticipation of possible future events*' and acknowledging that '*few studies have focused on how designers construct and use mental models of the future users of a product, as well as models of their needs*'. Yet, they are more concerned about the typology of thoughts a designer can have about future users rather than the mechanism behind those thoughts, its extension to users and its integration into method development. An interesting result from their work is the emphasis of '*counterfactual thinking*' defined as '*mental representations of alternatives to past events, actions or states*' (Epstude and Roese 2008; cited by Nelson, Buisine, and Aoussat 2013) as one possible mechanism allowing future thinking. They also highlight future thinking's vulnerability to biases such as foresight biases (MacKay and McKiernan 2004; cited by Nelson, Buisine, and Aoussat 2013).

The 56 relevant publications we surveyed do not really contain theories about future thinking as defined previously and are more in line with a classical HF&E approach (centred on the short-term future in relation to well-delimited events, risks, tasks etc. related to operators' activities). Nelson, Buisine, and Aoussat (2013) are the only ones

to touch upon future thinking as a key issue within HF&E and prospective ergonomics, but they do not clarify the theoretical roots of future thinking nor how to leverage it during user research. This shortcoming is the basis for the present review.

2.2/ Relevance of future thinking for HF&E

2.2.1/ How is FT different from other cognitive processes?

HF&E researchers and practitioners are familiar with many cognitive processes: prospective memory, prospective cognition, creative thinking, counterfactual thinking etc. What makes FT theory different is:

- **Specificity**. It encompasses and attempts to explain all future-oriented thought processes (e.g., prospective memory see Michaelian, Klein, and Szpunar 2016, 27; Eustache 2018b, 9) and only future-oriented thought processes. This specificity is also supported by distinctive neural correlates (see 2.3).
- **Theoretical distinctiveness**. FT theory explains phenomena that were not explained by other theories (namely, how thoughts of the future are created and directed). Other theories on cognitive processes, such as theories on creative thinking do not explain future thinking. FT is indeed part of what has been described as a new paradigm (Debus 2016), the mental-time travel paradigm, that encompasses both future thinking and past thinking (i.e., memory), argues for the idea that humans can be aware and direct their attention to both the past and future (ibid.), and is in rupture with previous ideas that considered them as distinct (Michaelian, Klein, and Szpunar 2016, 1).

2.2.2/ How is FT relevant to HF&E researchers and practitioners?

We argue for the importance of FT for HF&E specialists on the following bases:

- **Awareness**. Access to the FT corpus is difficult without bringing it to awareness explicitly to the HF&E community.
- **Theoretical consistency and conceptual clarity**. For a detailed primer on their importance see Schlagwein et al. (2019, 818–19), whose work brought to our attention the authors cited hereafter. Since the literature on future-oriented cognition used in HF&E is either scattered between different theoretical bodies or limited, there is a risk of '*construct identity fallacy*": distinct phenomena termed as identical or the same phenomenon labelled differently (Larsen and Bong 2016, 531). This potentially causes a risk of confusion, misunderstandings and conceptual mess, a waste of scientific time, and difficulties in theory unification and knowledge cumulation (ibid., 532). Clear definitions prevent findings from being incoherent and theories from remaining '*in the purgatory*' (Madge [1962, 538] cited by Schlagwein et al. [2019]). At last, one potential

drawback of a lack of conceptual development is a limited applicability (as shown in the case of agile methods by Conboy 2009).

- **Methodological improvement**. Since HF&E has shown interest in moving toward more future-oriented topics, it seems necessary to discuss relevant methods and theory to support this endeavour and ground it on the appropriate literature (see also section 7.4). More specifically, we expect two benefits for practitioners: a better collection of future needs, more efficient behavioural interventions.

  At the start of human-centred design is the collection of needs which is also one of the most difficult step because users are often unaware of them (Norman 2013, 9). Other hurdles stemming from both the user or the designer when collecting needs have been emphasised (Martin 2021, 76). Future needs are '*mental construct that corresponds to the operationalisation of pragmatic and hedonic basic needs in a future context […] by a user*' (Martin 2021, 74). Considering the difficulty to collect needs and the link between them and a future context, FT theory provides improved methodological and theoretical support for their collection.

  According to Moray (1995, 1693) the mission for the ergonomics of the future was the '*redesign of society to change human behaviour*'. On this regard, FT makes behavioural interventions easier. For example, episodic future thinking can improve maladaptive decision making such as health decisions (Rösch, Stramaccia, and Benoit 2021).

2.3/ The neuro-cognitive basis of future thinking

It might appear paradoxical, but future thinking (FT) relies on the memory system (Addis, Wong, and Schacter 2007; Buckner and Carroll 2007; Irish and Piguet 2013; D'Argembeau 2016b; Hollis-Hansen et al. 2019; Miloyan, McFarlane, and Suddendorf 2019). Indeed, the construction of FT events involves the access to both past episodic (personal, specific) and past semantic (general) pieces of information, which are then recombined to create mental representations of potential and realistic futures into which individuals can project themselves (Buckner and Carroll 2007; D'Argembeau 2016b; Schacter, Benoit, and Szpunar 2017).

At the neurological level, imagery studies confirmed the activation of the same brain areas during tasks aimed at remembering past events and tasks aimed at envisioning the future (Addis, Wong, and Schacter 2007; Schacter, Addis, and Buckner 2007; Schacter and Addis 2007; Szpunar, Watson, and McDermott 2007; Arzy et al. 2009; Viard et al. 2011). In terms of neural correlates, the so-called '*default mode network*' has been identified as crucial for FT (e.g., Buckner and Carroll 2007; Benoit and Schacter 2015). The default network includes regions such as the ventral medial prefrontal cortex, the posterior cingulate/retrosplenial cortex, the inferior parietal lobule, the lateral temporal cortex, the dorsal medial prefrontal cortex, and the hippocampal formation (Buckner,

Andrews-Hanna, and Schacter 2008).

2.4/ The functions of future thinking

Future thinking (FT) is central to human life by making simulation, prediction, intention and planning possible (Szpunar, Spreng, and Schacter 2014). Consequently, it enables humans to act flexibly based on realistic representations of the future, thus improving their chances of achieving short- and long-term goals (Suddendorf and Corballis 2007; Boyer 2008; D'Argembeau and Van der Linden 2012). In Table 2 we summarize the detailed functions of FT that have been proposed.

Table 2: Functions of future thinking

Functions of future thinking	References
Self-control, construction of a sense of identity	D'Argembeau & Demblon (2012)
Simulation, prediction, intention and planning	Szpunar, Spreng, & Schacter (2014)
Affective forecast, goal orientation, preparation for threats, flexible decision-making, deliberate practice	Bulley, Redshaw, & Suddendorf (2020)
Boredom reduction, death preparation, identity contrasting, negative emotion regulation, social bonding, goal setting, planning, problem-solving, decision-making, positive emotion regulation	Hallford & D'Argembeau (2020)
Planning, prospective memory, episodic foresight prospective memory, delay of gratification (related to the function of motive priority management according to Bischof-Kohler & Bischof, 2007), saving behaviour	Mazachowsky & Mahy (2020)

3/ Obstacles to future thinking

Despite its essential role, future thinking (FT) is not without difficulties. For example, Miloyan, Bulley, & Suddendorf (2015) uncovered rumination and retrieval biases causing anxiety and depression. Similarly to these inherent costs, poor FT abilities are putting people at risk of negative consequences. For instance, children with

lower FT abilities can suffer from negative impacts on their academic performance, personal safety, and social relationships (Mahy, Moses, and Kliegel 2014). Paradoxically, even rich FT simulations can likewise have negative impacts by being misattributed as an authentic event (Devitt and Addis 2016). Altogether, mental time travel is very problematic for human beings (Tetlock and Gardner 2016, 83). Users have to circumvent many obstacles to represent themselves artefacts that they do not know or that do not exist yet (Petiot and Yannou 2004; Anastassova, Mégard, and Burkhardt 2007; Anastassova and Mayora-Ibarra 2009; Loup-Escande et al. 2014; Bourgeois-Bougrine, Latorre, and Mourey 2018; Barré, Buisine, and Aoussat 2018), to imagine the future (Trope and Liberman 2003, 2010; Barré, Buisine, and Aoussat 2018; Bourgeois-Bougrine, Latorre, and Mourey 2018) and to imagine new needs (Sperandio 2001; cited by Anastassova 2006).

We highlight and detail below three contributing factors to good or poor FT abilities: temporal distance, memory systems disabilities, and cognitive biases. These factors are the most relevant for researchers and practitioners since they can be mitigated during user recruitment or controlled for by the research protocol.

3.1/ Temporal distance

The more temporally distant from the present the events and actions are, the less concrete, detailed and embodied the representations related to the event or action will be. This leads to biased judgments and predictions (Trope and Liberman 2003, 2010; D'Argembeau and Van der Linden 2004; D'Argembeau, Renaud, and Van der Linden 2011).

3.2/ Memory systems

Another obstacle to FT is the limitation of our memory systems. Populations with biological impairments to their memory systems might have difficulties with FT. They fall into three broad categories: children (Michaelian, Klein, and Szpunar 2016), elderly (ibid.), and people with accidental (such as patient KC; Tulving, 1985) or illness-induced memory impairments (e.g., Gamboz et al., 2010; Brown et al., 2013). In addition to biological impairments, our interactions with digital artefacts, in which we externalise more and more of our memories, have diminished our anticipation abilities (Eustache 2018a, 130). Conversely, a higher number of memories relevant to a topic (e.g., a decade of experience with smartphones) leads to a higher quality of future thoughts related to the topic (Frederiks et al. 2019a). Remarkably, age-related differences in FT abilities are not explained only by impaired retrieval; other hypotheses have been proposed, such as changes in narrative style, in abilities to recombine episodic details, and in the inhibition of task-irrelevant thoughts (Gaesser et al. 2011).

3.3/ Cognitive biases

Cognitive biases might also hinder the efficiency of our future thinking abilities. Nelson, Buisine, and Aoussat (2013) listed 3 examples of foresight biases: psychological inertia, hindsight bias, and unrealistic optimism. We describe them, and others, in Table 3 below.

Table 3: Seven cognitive bias that can have an effect on future thinking

Names	Descriptions	References
Psychological inertia	Focus on what is known, familiar or evident which block the thinking process.	(Savransky 2000)
Hindsight bias	Effect of the occurrence of a past event on the estimation of the likelihood of such event in the future. Overestimation of the likelihood of having predicted the occurrence of an event after it has happened.	(Fischhoff 1975; Arkes et al. 1988)
Unrealistic optimism	Overestimation of the likelihood of positive outcomes.	(Weinstein 1980)
Shifting baseline syndrome	The use of a subjective reference point as basis for the evaluation of changes (e.g., beginning of career, youth) instead of an objective one, thus skewing the evaluation of changes.	(Pauly 1995)
Planning fallacy	Underestimation of the time needed to complete a project.	(Kahneman and Tversky 1977)
Overconfidence effect	Overconfidence in one's	(Kahneman and Tversky

	abilities, performance, control and chance of success (‘*overestimation*’), overconfidence in one’s status compared to others (‘*better-than-average*’), overconfidence in one’s accuracy (‘*overprecision*’).	1977; Moore and Healy 2008)
Underestimation of the variability of continuous trends	Underestimation of the potential variability of events such as the movement of a storm or climate change.	(Wickens et al. 2020)

Most of the FT and future-oriented ergonomics literature is concerned with the general projection of the mind into the future, not with the accurate prediction of the future. As such, we do not expect biases to be as problematic in HF&E as in decision science. To the best of our knowledge, FT researchers do not currently integrate the study of biases within their work. Nevertheless, it is crucial to highlight debiasing (Kahneman and Tversky 1977; Fischhoff 1981) as an avenue for bias mitigation. The most intuitive debiasing method is to make the subject aware of the bias. This has been proven fruitless in the case of the hindsight bias (Arkes et al. 1988, 305) and overconfidence effect (Kahneman and Tversky 1977, 4–7). Fischhoff proposed three sources of bias that can be targeted by debiasing strategies (Fischhoff 1981, 4): faulty tasks (unfair and misunderstood tasks), faulty judges (perfectible individuals, incorrigible individuals), mismatch between judges and task (restructuring education). Currently, debiasing attempts are plagued by uncertainty regarding their long-term effect and their limitation to laboratory settings (Aczel et al. 2015). For additional and more recent reviews of debiasing strategies see Larrick (2004) and Soll, Milkman, and Payne (2015).

3.4/ Cognitive abilities and personality traits

Cognitive abilities could also play a role in FT. Individuals with higher visual imagery abilities (measured with the Vividness of Visual Imagery Questionnaire from Marks 1973) can imagine events with greater sensory details than individuals using emotion suppression strategies (D’Argembeau and Van der Linden 2006). Divergent thinking is also an important skill that influences the vividness of future events. According to Addis, Pan, Musicaro, & Schacter (2016), divergent thinking helps generate novel scenarios through the creative combination of disparate memories. D’Argembeau & Van der Linden’s research (2006) identified that people who engage in

mental imagery in day-to-day life are more likely to generate detailed mental representations of the personal future and past. As mentioned previously, FT abilities seem to be impaired by depression. Recently, Jeunehomme & D'Argembeau (2016) uncovered that future events envisioned by depressed individuals are less specific and less rich in episodic details.

Brosch, Stussi, Desrichard, & Sander (2018) conducted a study in which they measured participants' neural activation during projection tasks in the near and distant future. Participants with high self-improvement values (focused on maximizing self-interest) had higher activation when projecting into the near future. Participants with high self-transcendence values (focused on considering others' needs) had higher activation when projecting into the distant future. The authors explain that individuals with strong self-improvement values would suffer from '*myopia for the future*' because they focus on immediate consequences of their action when making a decision. In contrast, individuals with strong self-transcendence values are equally concerned about personal consequences as they are about the consequences for others and, therefore, for future generations.

4/ How to describe and assess future thinking events?

When performing user research, HF&E practitioners need to be able to classify a user's thought as future thinking (FT) or as some other kind of mental event. Debus (2016) proposes two distinctive features of FT events: '*subjective location in the future*' and '*openness*'. The former means that the subject identifies the event as happening in the future (in opposition to past or indistinct events). The latter means that the subjects are aware that they (or others) might act in ways that could cause or thwart the event.

Beyond those two conditions, practitioners might want to characterize an FT event more precisely (e.g., compare users, evaluate the efficiency of a method). Thus, it is essential to know descriptors (or *dimensions*) of FT events. Nine subjective dimensions of FT events have been identified and summarized in Table 4.

Table 4: List of nine subjective descriptors of future thinking events with corresponding recommendations and measurements (ordered alphabetically).

Descriptors	Definitions	References	Recommendations and measurements
Emotionality	Emotional nature, valence and intensity of an FT event.	D'Argembeau & Van der Linden (2004); Berntsen & Bohn (2010); Szpunar, Addis, & Schacter (2012)	Valence and intensity can be self-rated (D'Argembeau and Van der Linden 2004). Emotions can also be rated regarding their anticipated (the prediction of the emotional intensity) or anticipatory (how strongly thinking

			about the future event evokes the emotion) nature (e.g., for pleasure see Hallford et al. 2020).
Perceived control	Perceived influence of the subject over an FT event. Alternatively, it describes how easy to do the event/activity appears to be. It is sometimes referred to as controllability.	'Influence' sense (Jing, Madore, and Schacter 2016; Boland, Riggs, and Anderson 2018); 'perceived easiness' sense (Hallford et al. 2020).	Perceived control can be self-rated (ibid.)
Personal importance	Relevance of the event to the subject's life (goals, interests, life story, identity etc.).	Liberman & Trope (1998); Berntsen & Bohn (2010); D'Argembeau & Van der Linden (2012); Jeunehomme & D'Argembeau (2016); Noel, Saeremans, Kornreich, Jaafari, & D'Argembeau et al. (2017)	Personal importance can be self-rated directly (e.g., Jeunehomme and D'Argembeau 2016) or indirectly, e.g., by asking if the events will be thought or talked about a lot (Berntsen and Bohn 2010).
Perspective	Point of view of the pre-experienced event: first person (field perspective), third person (observer perspective), or neither.	D'Argembeau & Van der Linden (2004); Addis et al. (2008)	Perspective can be self-rated by the subject (e.g., D'Argembeau and Van der Linden 2004).
Plausibility	Likelihood of the FT event according to the subject.	Berntsen & Bohn (2010); Anderson (2012); Szpunar & Schacter (2013); McLelland, Devitt, Schacter, & Addis (2015); Jeunehomme & D'Argembeau (2016); D'Argembeau & Jimenez (2020)	Plausibility can be self-rated either through a single question (e.g., Berntsen and Bohn 2010) or through a scale such as the belief in occurrence scale (Scoboria et al. 2020).
Sensory modality	An event's sensory modality (or modalities)	D'Argembeau & Van der Linden (2006);	Berntsen & Bohn (2010) assessed this dimension by asking the participants a

	is the nature, range and quantity of the FT event's imagery (e.g., auditive, visual).	Berntsen & Bohn (2010)	question regarding the level (1 to 7 scale) to which they saw or heard '*in their mind*' what took place in the FT event.
Specificity	How distinct, brief and unique an FT event is.	Williams et al. (1996); D'Argembeau, Xue, Lu, Van der Linden, & Bechara (2008); D'Argembeau & Van der Linden (2012); D'Argembeau (2016b); Miloyan, McFarlane, & Suddendorf (2019)	Singer & Blagov (2000, 7–10) propose a complete classification of specific memories adaptable to FT events. It is of note that even if specificity is very often used (and thus used as the name of the dimension in this table), two other values of the descriptor are possible. Indeed according to Williams et al. (2000) events can also be '*extended*' (i.e., have a defined time-period that lasts longer than a day) or '*categoric*' (i.e., summarize a number or category of events).
Temporal distance	How far from the present is an FT event.	Liberman & Trope (1998); Addis et al. (2008); Noel, Saeremans, Kornreich, Jaafari, & D'Argembeau et al. (2017)	Temporal distance can be self-rated by the subject (e.g., Noël et al. 2017).
Vividness	Level of details of an FT event.	Marks (1973); Nelis, Holmes, Griffith, & Raes (2014); Devitt & Addis (2016)	Marks (1973) proposed the Vividness of Visual Imagery Questionnaire, Sheehan (1967) proposed the Questionnaire upon Mental Imagery. It is also possible to look at the level of details in descriptions of objects, place, people and context (date, time, place, etc.) according to D'Argembeau & Van der Linden (2004) and Noel, Saeremans, Kornreich, Jaafari, & D'Argembeau (2017).

We highlight the fact that:

(1) These dimensions are properties that shape the experience and impact FT events (e.g., see D'Argembeau and Van der Linden 2012). For example, FT events that are highly vivid, plausible and positive are more likely to be remembered and

thus beneficial for future behaviours (Devitt and Addis 2016), e.g., by informing decisions or needs.

(2) Some dimensions can be separated into subdimensions. For example, plausibility depends on feasibility (the ease or difficulty of reaching the end state, see Liberman and Trope 1998).

(3) The dimensions mentioned above contribute to the '*pre-experience*' (i.e., the degree to which the subject experiences sensory feelings related to the future) and '*autonoetic consciousness*' (i.e., the sense of being brought forward in time) meta-dimensions. For example, the feeling of pre-experience is increased by a field perspective (D'Argembeau and Van der Linden 2012), temporal distance and emotional valence (D'Argembeau and Van der Linden 2004). Furthermore, Hassabis, Kumaran, Vann, & Maguire (2007) suggest that pre-experience can be measured as a composite score of other descriptors (such as vividness). It can be self-rated by the participant (D'Argembeau and Van der Linden 2012).

(4) Other descriptors exist but since they are less common we did not include them in the table, e.g., ease of imagination, previous thinking about the event, the experience of a similar event in the past, the fact that the event has already been planned (D'Argembeau and Jimenez 2020, 10).

(5) Some descriptors can be applied to the whole FT event or to its components (e.g., personal significance can be applied to the components comprising future simulations as in McLelland et al. 2015).

(6) These and additional descriptors can also be used to assess the memories on which the FT event is built upon such as familiarity (how well a past event is known, see Anderson 2012; McLelland et al. 2015; and regarding its impact on vividness see D'Argembeau and Van der Linden 2012).

(7) Researchers can also use more 'objective' indicators to assess FT events' output such as those used for creativity tasks (fluency, novelty, feasibility and relevance, see Frederiks et al. 2019a), those aimed at measuring accuracy of probabilistic predictions (such as the Brier score, see Ungar et al. 2012) or those aimed at measuring the time needed to elicit an FT event (e.g., see D'Argembeau and Van der Linden 2004). Developing a standardized evaluation scale of FT based on these indicators and those listed in Table 4 is much needed.

5/ How to support future thinking?

In section 3, we emphasized the factors that make future thinking (FT) difficult for many. What can be done by the HF&E researcher to offset this difficulty? How, practically, can the researcher elicit 'good' future thinking? This section proposes both possible general recommendations (section 5.1) and specific tasks (section 5.2) related to FT priming and elicitation. The recommendations target different variations of FT; thus, the researcher should tailor its approach depending on its goals, e.g., eliciting rather episodic (personal, specific) or rather semantic future thinking (general); aiming at surface-level or in-depth elicitations.

Some research has started to incorporate these recommendations as a primer to improve the subsequent use of FT (e.g., Colin and Martin 2019; Frederiks et al. 2019a).

5.1/ General recommendations

5.1.1/ Support the retrieval of past experiences

The creation of mental representations of realistic futures is made possible by the recombination of past episodic and semantic information (Addis, Wong, and Schacter 2007; Schacter, Addis, and Buckner 2007; Irish and Piguet 2013; D'Argembeau 2016b; Hollis-Hansen et al. 2019; Miloyan, McFarlane, and Suddendorf 2019). Extraction of memories is among the early stages of FT followed by the recombination of details into novel and coherent events (Ernst and Manning 2016). To help participants to future-oriented studies, HF&E specialists could emphasize in their methods the retrieval of past experiences related to the studied topic (e.g., problems with smartphones, good experience during carpooling) or give instructions and cues that favour the retrieval of general and specific memories (e.g., Singer and Moffitt 1992; Williams et al. 1996). The more vivid the retrieved details are, the more they will offset temporal distance and allow imagining vivid events in return (D'Argembeau and Van der Linden 2012). In patients with multiple sclerosis suffering from cognitive impairments (among which, impairments to their anterograde memory), the use of mental visual imagery improves their autobiographical memory and FT abilities (Ernst et al. 2015).

5.1.2/ Start by building upon general details

According to the '*semantic scaffolding hypothesis*' (Irish and Piguet 2013), semantic (general) knowledge provides a structure that facilitates FT, especially when no related experience exists in the episodic memory. Thus, it is advisable first to construct a general representation of the future event based on memories before asking the subject to build upon this framework and add more episodic details.
For example, if HF&E specialists are trying to collect needs regarding the future of automated vehicles (AVs), with which very little users have direct experience, they could start by asking users general questions about their future: in what city will they live, with whom will they live, how will traffic be etc., before moving on to questions about automated vehicles.

5.1.3/ Aim at a detailed representation of the future

The level of detail of the representation is a factor in the projection's quality; it is essential to encourage individuals to imagine their experience in as much detail as possible (D'Argembeau and Van der Linden 2012; Noël et al. 2017). For example, HF&E specialists could use specific temporal- and context-related questions or even use cases, for example: 'In this situation, what would you think if the AV is slowing

down?', 'At this precise moment, before making your decision to cross the road, what are you thinking exactly?'.

5.1.4/ Bring the individuals to imagine themselves in the future event

If participants imagine themselves in a future personal context, it allows to pre-experience the event in an embodied way, thereby resulting in the emergence of a richer representation that includes sensory (D'Argembeau and Van der Linden 2012; Irish and Piguet 2013; Schacter, Addis, and Buckner 2007) and emotional elements. For example, HF&E specialists could ask questions regarding the sensory environment as well as emotional elements such as: 'Which textures and/or colours are on the vehicle's board?' and 'While you look at the AV's interface changing to automated functions, how does it make you feel?'.

5.1.5/ Activate high-order autobiographical and specific knowledge

It is advisable to activate specific and high-order autobiographical knowledge (such as personal goals) since they serve as guides in the simulation of episodic future events by providing frame and structure (D'Argembeau, Raffard, and Van der Linden 2008; D'Argembeau and Mathy 2011; D'Argembeau and Demblon 2012; D'Argembeau 2016a). For example, HF&E specialists could keep in mind specific and personal details about the participant (e.g., dog's name, preferences, etc.). When collecting insights into a future experience with AVs, these personal details could be used to anchor the participant narrative into his own future to avoid general storytelling about someone else's future or about his perception of mainstream ideas regarding the future of AVs. Practitioners should re-centre them by asking: 'You have described what people would do, but how would YOU do if you had an AV?' and 'How Billy, your dog, would react to AVs?'.

5.1.6/ Decrease temporal distance

If compatible with the goal of the study, decreasing temporal distance (see Table 4 for a definition) makes FT events more likely to be experienced at the first-person, more specific, more sensorial and richer in contextual details, (D'Argembeau and Van der Linden 2004, 2012). This is in line with construal-level theory (Trope and Liberman 2010) which states that with greater temporal distance, it is more likely that the simulation will be general, poorer in incidental details and based on amodal symbolic representations (abstract, poor in perceptual properties).
For example, if HF&E specialists are tasked with improving the efficiency of gambling rehab application, they could onboard users with a task requiring them to imagine changes they could make to their gambling behaviours within the next two weeks and what impacts these changes would have on their lives. Conversely, it will make FT more difficult if they request the user to imagine impacts in 6 months or more.

5.1.7/ Prioritize thinking about positive events

Given that individuals are generally optimistic about the future (Newby-Clark and Ross 2003), it is quicker for them to imagine positive than negative future events, and the events are more detailed and associated with a greater feeling of pre-experience (D'Argembeau and Van der Linden 2004). The representation of negative future events is therefore hindered and requires more time and resources. For example, focusing on AVs again, HF&E specialists could focus (at least in the beginning) on questions tackling positives impacts of AVs before getting into problem-solving about interactions' difficulties or expected incidents.

5.2/ Existing priming exercises

Beyond these general recommendations that could be included in future-oriented protocols, some existing '*projection tasks*' might also be considered. Projection tasks are cognitive tasks designed by psychologists to elicit or test FT functions. They could be used as primers/cues at the beginning of user research protocols or adapted as FT-centred alternatives to existing user research methods (such as semi-structured interviews).

5.2.1/ The Future Thinking Task (FTT)

The FTT (MacLeod et al. 1998) is a verbal fluency task in which participants are asked to imagine as many positive and/or negative experiences that will happen to them at three specific times (next week, next year, next 5 to 10 years). They are then asked to evaluate how they will feel at the time and how likely each experience is. Finally, the participants can also be asked to imagine the experiences deemed the most relevant in as much detail as possible in order to allow them a level of pre-experience (Noël et al. 2017). The Subjective Probability Task (MacLeod 1996) is an alternative and simpler version of the FTT, which involves asking participants to estimate the likelihood that a series of pre-determined negative/positive events will happen to them in the future.

5.2.2/ Future cueing

In the future cueing task, participants are asked to imagine specific episodes that may happen to them in the future. The imagination of these events is cued, that is, it is done in response to some stimuli: short sentences or words that evoke a specific/generic situation or feeling (e.g., '*a situation in which you feel guilty*' or '*bouquet*'). After the stimulus is presented, the participant is given a limited amount of time (e.g., 60 seconds) to imagine a future event (D'Argembeau et al. 2008; Williams et al. 1996). The resulting event is influenced by the specificity/generality of the stimuli (Williams et al. 1996). Alternative versions of this technique using pictures, audio or olfactory stimuli can be imagined.

5.2.3/ Adapted Autobiographical Interview

The Adapted Autobiographical Interview (Addis, Wong, and Schacter 2008; Miloyan, McFarlane, and Suddendorf 2019, 380) is a semi-structured interview that probes past and future events by asking participants to generate eight events from randomly generated cue words, in four different time conditions (two past and two future), and under three minutes per event in as many specific details as possible. The transcripts are then used to rate the richness, temporal distance, emotional intensity and personal significance of the events. There is an alternative cueing technique using photographs as stimuli (Gaesser et al. 2011).

5.2.4/ Experiential Index

The Experiential Index (Hassabis et al. 2007; Miloyan, McFarlane, and Suddendorf 2019, 380) is a semi-structured interview that brings participants to elaborate on short scenarios about the future (e.g., '*Imagine you're lying on a white sandy beach in a beautiful tropical bay*') in as many details as possible. The transcripts are then used to rate four variables: content, participant ratings, spatial coherence index, and quality judgments.

6/ Testing future thinking abilities

Recruiting participants with various future thinking (FT) abilities, measuring FT abilities as a control variable, assessing design methods etc., there are numerous reasons to look for ways to assess FT abilities. Yet, few tests exist. Most of them stem from psychopathology research where they are used to compare the FT abilities of individuals with various disabilities. We summarize them in Table 5 below. Some might require adaptations (e.g., shorter duration), nevertheless they will offer helpful references.

Table 5: Seven scales or tests of future thinking abilities

Name of the test	Description	Reference
Memory and Temporal Experience Questionnaire	This questionnaire assesses the plausibility of general (10 items) and specific (7 items) FT events.	Klein, Loftus, & Kihlstrom (2002)
Future Thinking Task	In addition to cueing FT, these tasks can also be used to rate FT abilities and compare participants.	See 5.2.1
Adapted Autobiographical Interview		See 5.2.3

Experiential Index		See 5.2.4
Functions of Future Thinking Scale	Measure the frequency of ten functions of FT (8 items per function, 80 items in total) and thus, how participants differ in their use of FT.	Hallford & D'Argembeau (2020)
Children's Future Thinking Questionnaire	Assesses the FT abilities in five functions of FT (8 to 9 items per function, 44 in total)	Mazachowsky & Mahy (2020)
Priming Manipulation Checks Scale	The scale was developed to measure how often participants experienced FT. The measurement consists of 4 items ranked on a five-point scale ('*never*' to '*very often*'). The 4 items are '*During the* [priming task], *I thought about the future even though I did not intend to do so'*; '*During the* [priming task], *I believed my thoughts about the future would definitely happen.*'; '*During the* [priming task*], images of the future popped into my mind*'; '*During the* [priming task], *I found myself daydreaming about the future.*'	Frederiks, Englis, Ehrenhard, & Groen (2019b, 2019a)

7/ Future research directions

We attempted to summarize key findings from future thinking (FT) research and how HF&E practitioners can use it to improve their future-oriented methods. Since it is a new approach within HF&E (and user-centred practice in general), additional work is needed to fully integrate FT in research and applied practices. As such, we highlight four avenues for the development of FT within the HF&E field: i) map FT processes to relevant priming tasks and clarify relations with other cognitive abilities, ii) explore expertise in mental time-travelling and trainability, iii) explore non-verbal dimensions of future thinking, and iv) develop new user research methods.

7.1/ The precise matching of future thinking processes with priming tasks and distinction with other imaginative abilities

First, there is a risk to consider FT as a monolithic ability. In reality, it is underwritten by distinct and successive mechanisms (Michaelian, Klein, and Szpunar 2016), therefore using FT in HF&E research would benefit from a precise mapping of FT mechanisms supplemented with the mention of relevant stimulation/elicitation tasks.

Second, FT is part of a 'galaxy' of other cognitive abilities. For example, it appears to be related to abilities such as mind-wandering, counterfactual thinking and theory of mind (Corballis 2016, 331–33; D'Argembeau 2016b, 204; De Brigard and Gessell 2016, 159–60; Pezzulo 2016, 272; Hallford et al. 2020, 8). Are some of the tasks aimed at stimulating or measuring these abilities usable (or adaptable) to prime FT?

7.2/ Explore expertise and trainability in future thinking

There is little idea as to what an '*ideal time traveller*' (an individual with exceptional FT abilities) would look like, but other fields such as political science identified several qualities of very accurate forecasters, called '*superforecasters*' (Tetlock and Gardner 2016). These results lend themselves to hypothesising the existence of a kind of '*prospective expertise*'.

This so-called '*expertise*' begs the question of training FT abilities. Can it be done? Seligman et al.'s (2013) review highlights the possibility of (re)training maladaptive future thinking abilities for psychotherapeutic purposes. In addition, a recent study by Hallford et al. (2020) shows the possibility of improving episodic FT, through substantial training, along several dimensions (i.e., specificity, vividness, plausibility etc.). Being able to train users and HF&E practitioners for FT would add another level to its impact on future-oriented research, most notably when working with people living in poverty whose temporal horizon can be impaired by challenging living conditions (Colombi 2020, 129–32). Speculative fiction author William Gibson once said, '*The future is already here – it's just not very evenly distributed.*' (Gladstone 1999). This is true for both the physical world and the mental world. Equitable access to future thinking is an issue. FT theory and methods could be a way to level the playing field and support the empowerment of disadvantaged communities regarding their future.

7.3/ Explore non-verbal dimensions of future thinking

The nine dimensions we proposed in section 4 to assess FT events could be complemented by non-verbal dimensions (e.g., limb or eye movements). Non-verbal dimensions are an essential cue during face-to-face techniques such as interviews according to Vermersch (2017, 51–52, 98–101). Indeed, the nine dimensions are mostly helpful for assessing the quality and quantity of the FT events after user research is completed. However, non-verbal dimensions could be used during user research and allow for live adjustments. The value of non-verbal dimensions has been noted by Berntsen & Bohn's (2010) who proposed physical/bodily reaction as a worthwhile descriptor for FT events. Some existing research provides support to this by linking eye movements (de Vito et al. 2015; El Haj and Lenoble 2018) or activation of pupil dilation (El Haj and Moustafa 2020) with FT events.

7.4/ Develop user research methods supported by future thinking theory

Miller (2018, 6) highlighted the lack of reflection, within the broader field of future studies, to the following question: '*What methods do we use to 'know the future'?*'. As an example of method development using FT theory, the '*needs anticipation interview*', is one of the possible answers to Miller's question. Within prospective ergonomics an interview technique is indeed under development to take into account FT (Brangier et al. 2018, 2019; Martin, Agnoletti, and Brangier 2021a; Martin 2021), i.e., it starts with general details (coherent with 5.1.2), activates personal goals

related (consistent with 5.1.5) and brings individuals to imagine their own future activities (coherent with 5.1.4). There is room for further improvements though and more could be done regarding methods such as personas (could '*prospective*' personas be written in a way that would improve HF&E practitioners' future thinking?, e.g., see Martin, Agnoletti, and Brangier [2021b]) or focus groups (could a group setting improve FT compared to an individual setting?).

8/ Conclusion

In this review we described future thinking (FT), the ability that allows for the mental simulation and/or pre-experience of future events of personal, general or hybrid nature. Indeed, despite a stronger emphasis than before on future-oriented studies in the HF&E field, very few researches leverage the understandings developed by neuroscientists and psychologists on that matter. In order to support HF&E researchers in doing so, the present synthesis highlighted the connections between memory systems and FT, the functions of FT in humans, the obstacles to FT, the descriptors of FT events, general recommendations and cueing/priming tasks, and possible assessment methods of FT functions (see Table 6 for a summary).

Table 6: Summary of research questions and findings

Research questions	Summary of findings
RQ1: What has been done previously on the topic of FT within HF&E? (see section 2.1)	Future-orientation is a rare topic within HF&E and has mostly been addressed using concepts such as 'prospective memory' and 'anticipation' that are distinct from FT and less useful for future-oriented or '*prospective*' user research.
RQ2: What are the neuro-cognitive bases of FT? (see section 2.3)	FT relies on the memory systems and the default mode network.
RQ3: What are the underlying functions of FT? (see section 2.4)	FT abilities make possible or partly support: simulation, prediction, intention and planning possible, achieving goals, affective forecast, goal orientation, preparation for threats, flexible decision-making, deliberate practice, motive priority management, boredom reduction, death preparation, identity contrasting, negative emotion regulation, social bonding, goal setting, planning, problem-solving, decision-making, positive emotion regulation, prospective memory,

	delay of gratification and saving behaviour.
RQ4: What are the obstacles to FT? (see section 3)	We categorized FT obstacles into three categories: temporal distance, limitations to our memory systems and cognitive biases.
RQ5: How can HF&E researchers and practitioners describe and measure FT events? (see section 4)	We identified nine common descriptors of FT events: emotionality, perceived control, personal importance, perspective, plausibility, sensory modality, specificity, temporal distance, vividness.
RQ6: What are possible recommendations as to the improvement elicitation of FT abilities? (see section 5.1)	We summarized seven general recommendations that could guide the creation of user research methods that rely on FT: support the retrieval of past experiences, build a general context of the future event, bring the individuals to imagine themselves in the future event, build a detailed representation about the future, activate personal goals, decrease temporal distance, target positive events first.
RQ7: How can researchers and practitioners prime/cue this ability in their protocols? (see section 5.2)	We identified four cueing/priming tasks of FT, namely: the Future Thinking Task, future cueing, the Adapted Autobiographical Interview and the Experiential Index.
RQ8: How to assess FT abilities? (see section 6)	We identified seven questionnaires, tasks and scales that currently provide means to assess FT abilities: the Memory and Temporal Experience Questionnaire, the Future Thinking Task, the Adapted Autobiographical Interview, the Experiential Index, the Functions of Future Thinking Scale, the Children's Future Thinking Questionnaire and the Priming Manipulation Checks Scale.

Contributions

C. Colin: Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing. **A. Martin:** Conceptualization, Investigation, Writing – review & editing. **F. Bonneviot:** Investigation, Writing – review & editing. **E. Brangier:** Supervision, Writing – review & editing.

Acknowledgements

We wish to thank the two anonymous reviewers for their helpful feedback regarding topics to clarify (biases and relevancy of FT) and improvements to the structure of the article.

Funding

This work has been partly supported by a CIFRE funding granted to Total S.E. by ANRT on behalf of the French Ministry of Higher Education, Research and Innovation. This work has been partly supported by the French PIA project « Lorraine Université d'Excellence », reference ANR-15-IDEX-04-LUE. This work has been partly supported by the Vedecom Institute.

References

Aczel, Balazs, Bence Bago, Aba Szollosi, Andrei Foldes, and Bence Lukacs. 2015. “Is It Time for Studying Real-Life Debiasing? Evaluation of the Effectiveness of an Analogical Intervention Technique.” *Frontiers in Psychology* 6. doi:10.3389/fpsyg.2015.01120.

Addis, Donna Rose, Ling Pan, Regina Musicaro, and Daniel L. Schacter. 2016. “Divergent Thinking and Constructing Episodic Simulations.” *Memory* 24 (1): 89–97. doi:10.1080/09658211.2014.985591.

Addis, Donna Rose, Alana T. Wong, and Daniel L. Schacter. 2007. “Remembering the Past and Imagining the Future: Common and Distinct Neural Substrates during Event Construction and Elaboration.” *Neuropsychologia* 45 (7): 1363–77. doi:10.1016/j.neuropsychologia.2006.10.016.

Addis, Donna Rose, Alana T Wong, and Daniel L Schacter. 2008. “Age-Related Changes in the Episodic Simulation of Future Events.” *Psychological Science* 19 (1): 33–41. doi:10.1111/j.1467-9280.2008.02043.x.

Allinc, Anaïs, Béatrice Cahour, and Jean-Marie Burkhardt. 2019. “The Guided Imaginary Projection, a New Methodology for Prospective Ergonomics.” In *Proceedings of the 20th Congress of the International Ergonomics Association (IEA 2018)*, edited by Sebastiano Bagnara, Riccardo Tartaglia, Sara Albolino, Thomas Alexander, and Yushi Fujita, 824:1340–47. Florence, Italia: Springer International Publishing. doi:10.1007/978-3-319-96071-5_135.

Anastassova, Margarita. 2006. “L’analyse ergonomique des besoins en amont de la conception de technologies émergente: le cas de la Réalité Augmentée pour la formation à la maintenance automobile.” Paris, France: Université René Descartes.

Anastassova, Margarita, and Oscar Mayora-Ibarra. 2009. “Elicitation of User Requirements for Mobile Interaction with Visual and RFID Tags: A Prototype-Based Exploratory Study.” In *Human Centered Design*, edited by Masaaki Kurosu, 5619:159–66. Lecture Notes in Computer Science. Berlin, Heidelberg: Springer Berlin Heidelberg. doi:10.1007/978-3-642-02806-9_19.

Anastassova, Margarita, Christine Mégard, and Jean-Marie Burkhardt, J-M. 2007. “Prototype Evaluation and User-Needs Analysis in the Early Design of Emerging Technologies.” In *Human-Computer Interaction. Interaction Design and Usability*, edited by Julie A. Jacko, 4550:383–92. Lecture Notes in Computer Science. Berlin, Heidelberg: Springer Berlin Heidelberg. doi:10.1007/978-3-540-73105-4_42.

Anderson, Rachel J. 2012. “Imagining Novel Futures: The Roles of Event Plausibility and Familiarity.” *Memory* 20 (5): 443–51. doi:10.1080/09658211.2012.677450.

Arkes, Hal R., David Faust, Thomas J. Guilmette, and Kathleen Hart. 1988. “Eliminating the Hindsight Bias.” *Journal of Applied Psychology* 73 (2): 305–7. doi:10.1037/0021-9010.73.2.305.

Arzy, Shahar, Sven Collette, Silvio Ionta, Eleonora Fornari, and Olaf Blanke. 2009. “Subjective Mental Time: The Functional Architecture of Projecting the Self to Past and Future.” *European Journal of Neuroscience* 30 (10): 2009–17. doi:10.1111/j.1460-9568.2009.06974.x.

Atance, Cristina M., and Daniela K. O’Neill. 2001. “Episodic Future Thinking.” *Trends in Cognitive Sciences* 5 (12): 533–39. doi:10.1016/S1364-6613(00)01804-0.

Barre, Jessy. 2015. “Vers de nouveaux outils pour l’anticipation des besoins utilisateurs : apports méthodologiques pour l’ergonomie prospective.” Paris, France: École Nationale Supérieure d’Arts et Métiers.

Barré, Jessy, Stéphanie Buisine, and Améziane Aoussat. 2018. “Persona Logical Thinking: Improving Requirements Elicitation for Multidisciplinary Teams.” *CoDesign* 14 (3): 218–37. doi:10.1080/15710882.2017.1301959.

Bartlett, Frederic. 1962. “The Future for Ergonomics.” *Ergonomics* 5 (4): 505–11. doi:10.1080/00140136208930653.

Benoit, Roland G., and Daniel L. Schacter. 2015. “Specifying the Core Network Supporting Episodic Simulation and Episodic Memory by Activation Likelihood Estimation.” *Neuropsychologia* 75: 450–57. doi:10.1016/j.neuropsychologia.2015.06.034.

Berntsen, D., and A. Bohn. 2010. “Remembering and Forecasting: The Relation between Autobiographical Memory and Episodic Future Thinking.” *Memory & Cognition* 38 (3): 265–78. doi:10.3758/MC.38.3.265.

Bischof-Köhler, Doris, and Norbert Bischof. 2007. “Is Mental Time Travel a Frame-of-Reference Issue?” *Behavioral and Brain Sciences* 30 (3). Cambridge University Press: 316–17. doi:10.1017/S0140525X07002014.

Boland, Jennifer, Kevin J. Riggs, and Rachel J. Anderson. 2018. “A Brighter Future: The Effect of Positive Episodic Simulation on Future Predictions in Non-Depressed, Moderately Dysphoric & Highly Dysphoric Individuals.” *Behaviour Research and Therapy* 100: 7–16. doi:10.1016/j.brat.2017.10.010.

Bonnardel, Nathalie, and John Didier. 2020. “Brainstorming Variants to Favor Creative Design.” *Applied Ergonomics* 83: 102987. doi:10.1016/j.apergo.2019.102987.

Bonnardot, Zoe, Yvon Haradji, Pascal Salembier, Elise Prieur, and Stephane Vial. 2020. “Anticiper Des Interactions Humaines Par Le Design et l’ergonomie : Le Partage d’énergies Renouvelables Entre Voisins.” In *Actes Du 55ème Congrès de La SELF*. Paris, France. https://mail.univ-lorraine.fr/service/home/~/?auth=co&loc=fr&id=106227&part=2.

Bourgeois-Bougrine, Samira, Souad Latorre, and Florence Mourey. 2018. “Promoting Creative Imagination of Non-Expressed Needs: Exploring a Combined Approach to Enhance Design Thinking.” *Creativity Studies* 11 (2): 377–94. doi:10.3846/cs.2018.7184.

Boyer, Pascal. 2008. “Evolutionary Economics of Mental Time Travel?” *Trends in Cognitive Sciences* 12 (6): 19–224. doi:10.1016/j.tics.2008.03.003.

Brangier, Eric, Blandine Brangier, Cathie Marache-Francisco, Steve Kopp, and Julien Clausse. 2018. “An Interview Process to Anticipate Future Needs.” In *Proceedings of the 20th Congress of the International Ergonomics Association*, edited by Sebastiano Bagnara, Riccardo Tartaglia, Sara Albolino, Thomas Alexander, and Yushi Fujita, 824:718–29. Florence, Italia: Springer. doi:10.1007/978-3-319-96071-5_76.

———. 2019. “An interview process to produce expertise on future needs.” In *Proceedings of the 16th Ergo’IA “Ergonomie Et Informatique Avancée” Conference*, 1–9. Bidart, France: ACM Press. doi:10.1145/3317326.3317340.

Brangier, Eric, and Jean-Marc Robert. 2014. “L’ergonomie prospective : fondements et enjeux.” *Le travail humain* 77 (1): 1–20. doi:10.3917/th.771.0001.

Brosch, Tobias, Yoann Stussi, Olivier Desrichard, and David Sander. 2018. “Not My Future? Core Values and the Neural Representation of Future Events.” *Cognitive, Affective, & Behavioral Neuroscience* 18 (3): 476–84. doi:10.3758/s13415-018-0581-9.

Brown, Adam D., James C. Root, Tracy A. Romano, Luke J. Chang, Richard A. Bryant, and William Hirst. 2013. “Overgeneralized Autobiographical Memory and Future Thinking in Combat Veterans with Posttraumatic Stress Disorder.” *Journal of Behavior Therapy and Experimental Psychiatry* 44 (1): 129–34. doi:10.1016/j.jbtep.2011.11.004.

Buckner, Randy L., Jessica R. Andrews-Hanna, and Daniel L. Schacter. 2008. “The Brain’s Default Network: Anatomy, Function, and Relevance to Disease.” *Annals of the New York Academy of Sciences* 1124 (1): 1–38. doi:10.1196/annals.1440.011.

Buckner, Randy L., and Daniel C. Carroll. 2007. “Self-Projection and the Brain.” *Trends in Cognitive Sciences* 11 (2): 49–57. doi:10.1016/j.tics.2006.11.004.

Bulley, Adam, Jonathan Redshaw, and Thomas Suddendorf. 2020. “The Future-Directed Functions of the Imagination: From Prediction to Metaforesight.” In *The Cambridge Handbook of the Imagination*, edited by Anna Abraham, 425–44. Cambridge, United Kingdom: Cambridge University Press. doi:10.1017/9781108580298.026.

Carroll, John M. 2013. “Creativity and Rationale: The Essential Tension.” In *Creativity and Rationale*, edited by John M. Carroll. Vol. 20. Human–Computer Interaction Series. London, United Kingdom: Springer. doi:10.1007/978-1-4471-4111-2_1.

Colin, Clément, and Antoine Martin. 2019. “Improving Mental Time Travel Abilities to Support the Collection of Needs: A Pilot Study.” In *Proceedings of the 50th Nordic Ergonomics and Human Factors Society Conference*, edited by Ole Broberg and Rikke Seim, 86–93. Elsinore, Denmark.

Colombi, Denis. 2020. *Où va l’argent Des Pauvres*. Essais Payot. Paris, France: Payot & Rivages.

Conboy, Kieran. 2009. “Agility from First Principles: Reconstructing the Concept of Agility in Information Systems Development.” *Information Systems Research* 20 (3): 329–54. doi:10.1287/isre.1090.0236.

Corballis, Michael C. 2016. “The Future of Memory, Mental Time Travel, and Mind Wandering.” In *Seeing the Future: Theoretical Perspectives on Future-Oriented Mental Time Travel*, edited by Kourken Michaelian, Stanley B. Klein, and Karl K. Szpunar, 328–39. Oxford, United Kingdom: Oxford University Press.

Daniellou, François. 2004. “L’ergonomie Dans La Conduite de Projets de Conception de Systèmes de Travail.” In L'Ergonomie, edited by Pierre Falzon, 359–73. Paris, France: Presses Universitaires de France. doi:10.3917/puf.falzo.2004.01.0359.

D’Argembeau, Arnaud. 2016a. “La Pensée Future Épisodique : Entre Simulation et Contexte Autobiographique.” *Revue de Neuropsychologie* 8 (1): 55–59. doi:10.3917/rne.081.0055.

———. 2016b. “The Role of Personal Goals in Future-Oriented Mental Time Travel.” In *Seeing the Future: Theoretical Perspectives on Future-Oriented Mental Time Travel*, edited by Kourken Michaelian, Stanley B. Klein, and Karl K. Szpunar, 199–214. Oxford, United Kingdom: Oxford University Press.

D’Argembeau, Arnaud, and Julie Demblon. 2012. “On the Representational Systems Underlying Prospection: Evidence from the Event-Cueing Paradigm.” *Cognition* 125 (2): 160–67. doi:10.1016/j.cognition.2012.07.008.

D’Argembeau, Arnaud, and Claudia Garcia Jimenez. 2020. “The Predictive Validity of Belief in Future Occurrence.” *Applied Cognitive Psychology*. doi:10.1002/acp.3708.

D'Argembeau, Arnaud, and Arnaud Mathy. 2011. "Tracking the Construction of Episodic Future Thoughts." *Journal of Experimental Psychology: General* 140 (2): 258–71. doi:10.1037/a0022581.

D'Argembeau, Arnaud, Stéphane Raffard, and Martial Van der Linden. 2008. "Remembering the Past and Imagining the Future in Schizophrenia." *Journal of Abnormal Psychology* 117 (1): 247–51. doi:10.1037/0021-843X.117.1.247.

D'Argembeau, Arnaud, Olivier Renaud, and Martial Van der Linden. 2011. "Frequency, Characteristics and Functions of Future-Oriented Thoughts in Daily Life." *Applied Cognitive Psychology* 25 (1): 96–103. doi:10.1002/acp.1647.

D'Argembeau, Arnaud, and Martial Van der Linden. 2004. "Phenomenal Characteristics Associated with Projecting Oneself Back into the Past and Forward into the Future: Influence of Valence and Temporal Distance." *Consciousness and Cognition* 13 (4): 844–58. doi:10.1016/j.concog.2004.07.007.

———. 2006. "Individual Differences in the Phenomenology of Mental Time Travel: The Effect of Vivid Visual Imagery and Emotion Regulation Strategies." *Consciousness and Cognition* 15 (2): 342–50. doi:10.1016/j.concog.2005.09.001.

———. 2012. "Predicting the Phenomenology of Episodic Future Thoughts." *Consciousness and Cognition* 21 (3): 1198–1206. doi:10.1016/j.concog.2012.05.004.

D'Argembeau, Arnaud, Gui Xue, Zhong-Lin Lu, Martial Van der Linden, and Antoine Bechara. 2008. "Neural Correlates of Envisioning Emotional Events in the near and Far Future." *NeuroImage* 40 (1): 398–407. doi:10.1016/j.neuroimage.2007.11.025.

De Brigard, Felipe, and Bryce S. Gessell. 2016. "Time Is Not of the Essence: Understanding the Neural Correlates of Mental Time Travel." In *Seeing the Future: Theoretical Perspectives on Future-Oriented Mental Time Travel*, edited by Kourken Michaelian, Stanley B. Klein, and Karl K. Szpunar, 153–79. Oxford, United Kingdom: Oxford University Press.

De Greene, Kenyon B. 1980. "Major Conceptual Problems in the Systems Management of Human Factors/Ergonomics Research." *Ergonomics* 23 (1): 3–11. doi:10.1080/00140138008924713.

Debus, Dorothea. 2016. "Temporal Perspectives in Imagination: On the Nature and Value of Imagining the Future." In *Seeing the Future: Theoretical Perspectives on Future-Oriented Mental Time Travel*, edited by Kourken Michaelian, Stanley B. Klein, and Karl K. Szpunar, 217–40. Oxford, United Kingdom: Oxford University Press.

Devitt, Aleea L., and Donna Rose Addis. 2016. "Bidirectional Interactions between Memory and Imagination." In *Seeing the Future: Theoretical Perspectives on Future-Oriented Mental Time Travel*, edited by Kourken Michaelian, Stanley B. Klein, and Karl K. Szpunar, 93–115. Oxford, United Kingdom: Oxford University Press.

Dong, Andy, Emma Collier-Baker, and Thomas Suddendorf. 2017. "Building Blocks of Human Design Thinking in Animals." *International Journal of Design Creativity and Innovation* 5 (1–2): 1–15. doi:10.1080/21650349.2015.1011700.

Duarte, Francisco, and Francisco Lima. 2012. "Anticiper l'activité par les configurations d'usage : proposition méthodologique pour conduite de projet." *Activités* 09 (9–2). doi:10.4000/activites.314.

Dunne, Anthony, and Fiona Raby. 2013. *Speculative Everything: Design, Fiction, and Social Dreaming*. Cambridge, USA: The MIT Press.

El Haj, Mohamad, and Quentin Lenoble. 2018. “Eying the Future: Eye Movement in Past and Future Thinking.” *Cortex*, The Eye’s Mind - visual imagination, neuroscience and the humanities, 105: 97–103. doi:10.1016/j.cortex.2017.05.024.

El Haj, Mohamad, and Ahmed A. Moustafa. 2020. “Pupil Dilation as an Indicator of Future Thinking.” *Neurological Sciences*. doi:10.1007/s10072-020-04533-z.

Epstude, Kai, and Neal J. Roese. 2008. “The Functional Theory of Counterfactual Thinking.” *Personality and Social Psychology Review* 12 (2): 168–92. doi:10.1177/1088868308316091.

Ernst, Alexandra, Frédéric Blanc, Jérôme De Seze, and Liliann Manning. 2015. “Using Mental Visual Imagery to Improve Autobiographical Memory and Episodic Future Thinking in Relapsing-Remitting Multiple Sclerosis Patients: A Randomised-Controlled Trial Study.” *Restorative Neurology and Neuroscience* 33 (5): 621–38. doi:10.3233/RNN-140461.

Ernst, Alexandra, and Liliann Manning. 2016. “The Impact of Multiple Sclerosis on Future-Oriented Mental Time Travel: Neuropsychological and Neuroimagining Approaches.” In *Seeing the Future: Theoretical Perspectives on Future-Oriented Mental Time Travel*, edited by Kourken Michaelian, Stanley B. Klein, and Karl K. Szpunar, 409–28. Oxford, United Kingdom: Oxford University Press.

Eustache, Francis. 2018a. “A La Recherche d’un Futur Perdu ?” In *La Mémoire Au Futur*, 125–36. Paris, France: Le Pommier/Humensis.

———. 2018b. *La Mémoire Au Futur*. Paris, France: Le Pommier/Humensis.

Faste, Rolf A. 1987. “Perceiving Needs.” In . doi:10.4271/871534.

Fischhoff, Baruch. 1975. “Hindsight ≠ Foresight: The Effect of Outcome Knowledge on Judgment under Uncertainty.” *Journal of Experimental Psychology: Human Perception and Performance* 1: 288–99. doi:10.1136/qhc.12.4.304.

———. 1981. “Debaising.” PTR-1092-81-3. Advanced Decision Technology Program. https://apps.dtic.mil/sti/pdfs/ADA099435.pdf.

Frederiks, Arjan J., Basil G. Englis, Michel L. Ehrenhard, and Aard J. Groen. 2019a. “Entrepreneurial Cognition and the Quality of New Venture Ideas: An Experimental Approach to Comparing Future-Oriented Cognitive Processes.” *Journal of Business Venturing* 34 (2): 327–47. doi:10.1016/j.jbusvent.2018.05.007.

———. 2019b. “Priming Manipulation Checks Scale.”

Gaesser, Brendan, Daniel C. Sacchetti, Donna Rose Addis, and Daniel L. Schacter. 2011. “Characterizing Age-Related Changes in Remembering the Past and Imagining the Future.” *Psychology and Aging* 26 (1): 80–84. doi:10.1037/a0021054.

Gamboz, Nadia, Stefania De Vito, Maria A. Brandimonte, Stella Pappalardo, Filomena Galeone, Alessandro Iavarone, and Sergio Della Sala. 2010. “Episodic Future Thinking in Amnesic Mild Cognitive Impairment.” *Neuropsychologia* 48 (7): 2091–97. doi:10.1016/j.neuropsychologia.2010.03.030.

Gilbert, Daniel T., and Timothy D. Wilson. 2007. “Prospection: Experiencing the Future.” *Science* 317 (5843): 1351–54. doi:10.1126/science.1144161.

Gladstone, Brooke. 1999. “The Science in Science Fiction.” *Talk of the Nation*. National Public Radio. https://www.npr.org/2018/10/22/1067220/the-science-in-science-fiction?t=1605774253901.

Hallford, David J., and Arnaud D'Argembeau. 2020. "Why We Imagine Our Future: Introducing the Functions of Future Thinking Scale (FoFTS)." Preprint. PsyArXiv. doi.org/10.31234/osf.io/bez4u.

Hallford, David J., Joseph Yeow, Grace Fountas, C.A. Herrick, Filip Raes, and Arnaud D'Argembeau. 2020. "Changing the Future: An Initial Test of Future Specificity Training (FeST)." *Behaviour Research and Therapy* 131: 103638. doi:10.1016/j.brat.2020.103638.

Hassabis, Demis, Dharshan Kumaran, Seralynne D. Vann, and Eleanor A. Maguire. 2007. "Patients with Hippocampal Amnesia Cannot Imagine New Experiences." *Proceedings of the National Academy of Sciences* 104 (5): 1726–31. doi:10.1073/pnas.0610561104.

Hollis-Hansen, Kelseanna, Sara E. O'Donnell, Jennifer S. Seidman, Spencer J. Brande, and Leonard H. Epstein. 2019. "Improvements in Episodic Future Thinking Methodology: Establishing a Standardized Episodic Thinking Control." *PLOS ONE* 14 (3): e0214397. doi:10.1371/journal.pone.0214397.

Irish, Muireann, and Olivier Piguet. 2013. "The Pivotal Role of Semantic Memory in Remembering the Past and Imagining the Future." *Frontiers in Behavioral Neuroscience* 7 (27). doi:10.3389/fnbeh.2013.00027.

Jeunehomme, Olivier, and Arnaud D'Argembeau. 2016. "Prevalence and Determinants of Direct and Generative Modes of Production of Episodic Future Thoughts in the Word Cueing Paradigm." *Quarterly Journal of Experimental Psychology* 69 (2): 254–72. doi:10.1080/17470218.2014.993663.

Jing, Helen G., Kevin P. Madore, and Daniel L. Schacter. 2016. "Worrying about the Future: An Episodic Specificity Induction Impacts Problem Solving, Reappraisal, and Well-Being." *Journal of Experimental Psychology: General* 145 (4): 402–18. doi:10.1037/xge0000142.

Kahneman, Daniel, and Amos Tversky. 1977. "Intuitive Prediction: Biases and Corrective Procedures." PTR-1042-7746. Advanced Decision Technology Program. https://apps.dtic.mil/sti/pdfs/ADA047747.pdf.

Klein, Stanley B., Judith Loftus, and John F. Kihlstrom. 2002. "Memory and Temporal Experience: The Effects of Episodic Memory Loss on an Amnesic Patient's Ability to Remember the Past and Imagine the Future." *Social Cognition* 20 (5): 353–79. doi:10.1521/soco.20.5.353.21125.

Larrick, Richard P. 2004. "Debiasing." In *Blackwell Handbook of Judgment and Decision Making*, 316–38. John Wiley & Sons, Ltd. https://onlinelibrary.wiley.com/doi/abs/10.1002/9780470752937.ch16.

Larsen, Kai R., and Chih How Bong. 2016. "A Tool for Addressing Construct Identity in Literature Reviews and Meta-Analyses." *MIS Quarterly* 40 (3): 529–51. doi:10.25300/MISQ/2016/40.3.01.

Laurig, Wolfgang. 1984. *Prospektive Ergonomie - Utopie Oder Wirklichkeit?* Schriftenreihe Arbeitswissenschaft Des AGV Metall Köln 9. Koln, Germany: Arbeitgeberverband der Metallindustrie Köln.

———. 1986. "Prospective Ergonomics - A New Approach to Industrial Ergonomics." In *Trends in Ergonomics / Human Factors III*, edited by Waldemar Karwowski, Part A:41–50. Louisville, USA: Elsevier.

———. 1992. "Prinzip: Prospektive Ergonomie Verwirklichen Anstatt Nur Mit Korrektiver Ergonomie Nachbessern Zu Wollen." In *Grundzüge Der Ergonomie : Erkenntnisse Und*

Prinzipien, 195–200. REFA-Verband Für Arbeitsstudien Und Betriebsorganisation. Beuth Verlag GmbH.

Laurig, Wolfgang, and Joachim Vedder. 1998. "Overview." In , edited by Jeanne Mager Stellman, 4th edition, 1:29.2. Geneva, Switzerland: International Labour Organization. http://www.ilocis.org/documents/chpt29e.htm.

Liberman, Nira, and Yaacov Trope. 1998. "The Role of Feasibility and Desirability Considerations in near and Distant Future Decisions: A Test of Temporal Construal Theory." *Journal of Personality and Social Psychology* 75 (1): 5–18. doi:10.1037/0022-3514.75.1.5.

Loup-Escande, Emilie, Jean-Marie Burkhardt, Olivier Christmann, and Simon Richir. 2014. "Needs' Elaboration between Users, Designers and Project Leaders: Analysis of a Design Process of a Virtual Reality-Based Software." *Information and Software Technology* 56 (8): 1049–61. doi:10.1016/j.infsof.2014.04.008.

Loup-Escande, Emilie. 2019. "Concevoir Des Technologies Émergentes Acceptables : Complémentarité Des Approches Expérimentale, Écologique et Prospective." Habilitation à diriger des recherches, Amiens, France: Université de Picardie Jules Verne.

Loup-Escande, Emilie, and Guillaume Loup. 2020. "Designing Acceptable Emerging Technologies: What Contribution from Ergonomics?" *Theoretical Issues in Ergonomics Science*, 1–22. doi:10.1080/1463922X.2020.1836568.

MacKay, R. Bradley, and Peter McKiernan. 2004. "The Role of Hindsight in Foresight: Refining Strategic Reasoning." *Futures*, Coping with the Future: Developing Organizational Foresightfulness, 36 (2): 161–79. doi:10.1016/S0016-3287(03)00147-2.

MacLeod, Andrew K. 1996. "Affect, Emotional Disorder, and Future-Directed Thinking." *Cognition & Emotion* 10 (1): 69–86. doi:10.1080/026999396380394.

MacLeod, Andrew K., Philip Tata, Kathryn Evans, Peter Tyrer, Ulrike Schmidt, Kate Davidson, Susan Thornton, and Jose Catalan. 1998. "Recovery of Positive Future Thinking within a High-Risk Parasuicide Group: Results from a Pilot Randomized Controlled Trial." *British Journal of Clinical Psychology* 37 (4): 371–79. doi:10.1111/j.2044-8260.1998.tb01394.x.

Madge, John Hylton. 1962. *The Origins of Scientific Sociology*. New York, USA: The Free Press.

Mahy, Caitlin E.V., Louis J. Moses, and Matthias Kliegel. 2014. "The Development of Prospective Memory in Children: An Executive Framework." *Developmental Review* 34 (4): 305–26. doi:10.1016/j.dr.2014.08.001.

Marks, David F. 1973. "Visual Imagery Differences in the Recall of Pictures." *British Journal of Psychology* 64 (1): 17–24. doi:10.1111/j.2044-8295.1973.tb01322.x.

Martin, Antoine. 2021. "Méthodes d'ergonomie Prospective Pour l'exploration Des Besoins Futurs." Metz, France: Université de Lorraine.

Martin, Antoine, Marie-France Agnoletti, and Eric Brangier. 2021a. "Ordinary Users, Precursory Users and Experts in the Anticipation of Future Needs: Evaluation of Their Contribution in the Elaboration of New Needs in Energy for Housing." *Applied Ergonomics* 94. doi:10.1016/j.apergo.2021.103394.

Martin, Antoine, Marie-France Agnoletti, and Éric Brangier. 2021b. "Improve Creativity in Future-Oriented Design with the Prospective Persona." In *Proceedings of the 21st*

Congress of the International Ergonomics Association (IEA 2021). IEA 2021. Lecture Notes in Networks and Systems, 726–36. doi:10.1007/978-3-030-74602-5_99.

Mazachowsky, Tessa R., and Caitlin E. V. Mahy. 2020. "Constructing the Children's Future Thinking Questionnaire: A Reliable and Valid Measure of Children's Future-Oriented Cognition." *Developmental Psychology* 56 (4): 756–72. doi:10.1037/dev0000885.

McLelland, Victoria C., Aleea L. Devitt, Daniel L. Schacter, and Donna Rose Addis. 2015. "Making the Future Memorable: The Phenomenology of Remembered Future Events." *Memory* 23 (8): 1255–63. doi:10.1080/09658211.2014.972960.

Michaelian, Kourken, Stanley B. Klein, and Karl K. Szpunar. 2016. "The Past, the Present, and the Future of Future-Oriented Mental Time Travel." In *Seeing the Future: Theoretical Perspectives on Future-Oriented Mental Time Travel*, edited by Kourken Michaelian, Stanley B. Klein, and Karl K. Szpunar, 1–18. Oxford, United Kingdom: Oxford University Press. doi:10.1093/acprof:oso/9780190241537.003.0001.

Miller, Riel. 2007. "Futures Literacy: A Hybrid Strategic Scenario Method." *Futures* 39 (4): 341–62. doi:10.1016/j.futures.2006.12.001.

———, ed. 2018. *Transforming the Future*. New York, USA: Routledge.

Miloyan, Beyon, Adam Bulley, and Thomas Suddendorf. 2015. "Episodic Foresight and Anxiety: Proximate and Ultimate Perspectives." *British Journal of Clinical Psychology* 55 (1): 4–22. doi:10.1111/bjc.12080.

Miloyan, Beyon, Kimberley A. McFarlane, and Thomas Suddendorf. 2019. "Measuring Mental Time Travel: Is the Hippocampus Really Critical for Episodic Memory and Episodic Foresight?" *Cortex* 117: 371–84. doi:10.1016/j.cortex.2019.01.020.

Montmollin, Maurice de. 1967. *Les Systèmes Hommes-Machines : Introduction à l'ergonomie*. Paris, France: Presses Universitaires de France.

Moore, Don A., and Paul J. Healy. 2008. "The Trouble with Overconfidence." *Psychological Review* 115 (2): 502–17. doi:10.1037/0033-295X.115.2.502.

Moray, Neville. 1995. "Ergonomics and the Global Problems of the Twenty-First Century." *Ergonomics* 38. doi:10.1080/00140139508925220.

Navarro, Jordan. 2019. "A State of Science on Highly Automated Driving." *Theoretical Issues in Ergonomics Science* 20 (3): 366–96. doi:10.1080/1463922X.2018.1439544.

Nelis, Sabine, Emily A. Holmes, James W. Griffith, and Filip Raes. 2014. "Mental Imagery during Daily Life: Psychometric Evaluation of the Spontaneous Use of Imagery Scale (SUIS)." *Psychologica Belgica* 54 (1): 19–32. doi:10.5334/pb.ag.

Nelson, Julien. 2019. "Ergonomie Prospective, Technologies Émergentes et Créativité." Habilitation à diriger des recherches, Metz, France: Université de Lorraine.

Nelson, Julien, Stéphanie Buisine, and Améziane Aoussat. 2013. "Anticipating the Use of Future Things: Towards a Framework for Prospective Use Analysis in Innovation Design Projects." *Applied Ergonomics* 44 (6): 948–56. doi:10.1016/j.apergo.2013.01.002.

Newby-Clark, Ian R., and Michael Ross. 2003. "Conceiving the Past and Future." *Personality and Social Psychology Bulletin* 29 (7): 807–18. doi:10.1177/0146167203029007001.

Noël, Xavier, Mélanie Saeremans, Charles Kornreich, Nematollah Jaafari, and Arnaud D'Argembeau. 2017. "Future-Oriented Mental Time Travel in Individuals with Disordered Gambling." *Consciousness and Cognition* 49: 227–36. doi:10.1016/j.concog.2017.02.006.

Norman, Donald A. 2013. *The Design of Everyday Things*. Basic Books.

Pauly, Daniel. 1995. “Anecdotes and the Shifting Baseline Syndrome of Fisheries.” *Trends in Ecology & Evolution* 10 (10): 430. doi:10.1016/S0169-5347(00)89171-5.

Petiot, Jean-François, and Bernard Yannou. 2004. “Measuring Consumer Perceptions for a Better Comprehension, Specification and Assessment of Product Semantics.” *International Journal of Industrial Ergonomics* 33 (6): 507–25. doi:10.1016/j.ergon.2003.12.004.

Pettersson, Ingrid, and I. C. MariAnne Karlsson. 2015. “Setting the Stage for Autonomous Cars: A Pilot Study of Future Autonomous Driving Experiences.” *IET Intelligent Transport Systems* 9 (7). IET Digital Library: 694–701. doi:10.1049/iet-its.2014.0168.

Pezzulo, Giovanni. 2016. “The Mechanisms and Benefits of a Future- Oriented Brain.” In *Seeing the Future: Theoretical Perspectives on Future-Oriented Mental Time Travel*, edited by Kourken Michaelian, Stanley B. Klein, and Karl K. Szpunar, 267–84. Oxford, United Kingdom: Oxford University Press.

Riegler, Alexander. 2001. “The Role of Anticipation in Cognition.” In *AIP Conference Proceedings*, 573:534–41. Liege, Belgium: AIP. doi:10.1063/1.1388719.

Robert, Jean-Marc, and Eric Brangier. 2009. “What Is Prospective Ergonomics? A Reflection and a Position on the Future of Ergonomics.” In *Proceedings of the International Conference on Ergonomics and Health Aspects of Work with Computers*, edited by Ben-Tzion Karsh, 5624:162–69. San Diego, USA: Springer. doi:10.1007/978-3-642-02731-4_19.

———. 2012. “Prospective Ergonomics: Origin, Goal, and Prospects.” *Work*, no. Supplement 1: 5235–42. doi:10.3233/WOR-2012-0012-5235.

———. 2019. “Overview of Methods for Prospective Ergonomics.” In *Proceedings of the 50th Nordic Ergonomics and Human Factors Society Conference*, 77–85. Elsinore, Denmark.

Rösch, Sarah Alica, Davide Francesco Stramaccia, and Roland Georg Benoit. 2021. “Promoting Farsighted Decisions via Episodic Future Thinking: A Meta-Analysis.” PsyArXiv. doi:10.31234/osf.io/53ju2.

Rosen, Michael A., Eduardo Salas, Davin Pavlas, Randy Jensen, Dan Fu, and Donald Lampton. 2010. “Demonstration-Based Training: A Review of Instructional Features.” *Human Factors* 52 (5): 596–609. doi:10.1177/0018720810381071.

Sagot, Jean-Claude, Valérie Gouin, and Samuel Gomes. 2003. “Ergonomics in Product Design: Safety Factor.” *Safety Science* 41 (2–3): 137–54. doi:10.1016/S0925-7535(02)00038-3.

Savransky, Semyon D. 2000. *Engineering of Creativity: Introduction to TRIZ Methodology of Inventive Problem Solving*. CRC Press. doi:10.1201/9781420038958.

Saward, Justin R.E., and Neville A. Stanton. 2015. “Individual Latent Error Detection and Recovery in Naval Aircraft Maintenance: Introducing a Proposal Linking Schema Theory with a Multi-Process Approach to Human Error Research.” *Theoretical Issues in Ergonomics Science* 16 (3): 255–72. doi:10.1080/1463922X.2014.969360.

Schacter, Daniel L., and Donna Rose Addis. 2007. “The Cognitive Neuroscience of Constructive Memory: Remembering the Past and Imagining the Future.” *Philosophical Transactions of the Royal Society B: Biological Sciences* 362 (1481): 773–86. doi:10.1098/rstb.2007.2087.

Schacter, Daniel L., Donna Rose Addis, and Randy L. Buckner. 2007. “Remembering the Past to Imagine the Future: The Prospective Brain.” *Nature Reviews Neuroscience* 8 (9): 657–61. doi:10.1038/nrn2213.

Schacter, Daniel L, Roland G Benoit, and Karl K. Szpunar. 2017. “Episodic Future Thinking: Mechanisms and Functions.” *Current Opinion in Behavioral Sciences* 17: 41–50. doi:10.1016/j.cobeha.2017.06.002.

Schlagwein, Daniel, Detlef Schoder, and Kai Spindeldreher. 2019. “Consolidated, Systemic Conceptualization, and Definition of the ‘Sharing Economy.’” *Journal of the Association for Information Science and Technology* 71 (7): 817–38. doi:10.1002/asi.24300.

Schmorrow, Dylan, and Sae Schatz. 2016. “The Future of Learning: Implications for Humans, Adaptive Systems, and Instructional Technologies.” *Theoretical Issues in Ergonomics Science* 17 (2): 125–26. doi:10.1080/1463922X.2015.1111464.

Scoboria, Alan, Giuliana Mazzoni, Alexandra Ernst, and Arnaud D’Argembeau. 2020. “Validating ‘Belief in Occurrence’ for Future Autobiographical Events.” *Psychology of Consciousness: Theory, Research, and Practice* 7 (1): 4–29. doi:10.1037/cns0000193.

Seligman, Martin E P, Peter Railton, Roy F Baumeister, and Chandra Sripada. 2013. “Navigating into the Future or Driven by the Past.” *Perspectives on Psychological Science* 8 (2): 119–41. doi:10.1177/1745691612474317.

Sheehan, Peter Winston. 1967. “A Shortened Form of Betts’ Questionnaire upon Mental Imagery.” *Journal of Clinical Psychology* 23 (3): 386–89. doi:10.1002/1097-4679(196707)23:3<386::AID-JCLP2270230328>3.0.CO;2-S.

Singer, Jefferson A, and Pavel S Blagov. 2000. “Classification System and Scoring Manual for Self-Defining Autobiographical Memories.” http://www.selfdefiningmemories.com/Classification_System___Scoring_Manual_for_SDMs.pdf.

Singer, Jefferson A., and Kathie Halbach Moffitt. 1992. “An Experimental Investigation of Specificity and Generality in Memory Narratives.” *Imagination, Cognition and Personality* 11 (3): 233–57. doi:10.2190/72A3-8UPY-GDB9-GX9K.

Soll, Jack B., Katherine L. Milkman, and John W. Payne. 2015. “A User’s Guide to Debiasing.” In *The Wiley Blackwell Handbook of Judgment and Decision Making*, edited by Gideon Keren and George Wu, 924–51. Chichester, United Kindgom: John Wiley & Sons, Ltd. doi:10.1002/9781118468333.ch33.

Sperandio, Jean-Claude. 2001. “Critères Ergonomiques de l’assistance Technologiques Aux Opérateurs.” In . Metz, France.

Sterling, Bruce. 2005. *Shaping Things*. Cambridge, USA: MIT Press.

Suddendorf, Thomas, and Michael C. Corballis. 2007. “The Evolution of Foresight: What Is Mental Time Travel, and Is It Unique to Humans?” *Behavioral and Brain Sciences* 30 (3): 299–351. doi:10.1017/S0140525X07001975.

Suhir, Ephraim, Sami Lini, Christophe Bey, Jean-Marc Salotti, Sylvain Hourlier, and Bernard Claverie. 2015. “Probabilistic Modelling of the Concept of Anticipation in Aviation.” *Theoretical Issues in Ergonomics Science* 16 (1): 69–85. doi:10.1080/1463922X.2014.895878.

Sutter, Jean. 1990. *L’anticipation*. 2nd ed. Psychiatrie Ouverte. Paris, France: Presses Universitaires de France.

Szpunar, Karl K., Donna Rose Addis, and Daniel L. Schacter. 2012. “Memory for Emotional Simulations: Remembering a Rosy Future.” *Psychological Science* 23 (1): 24–29. doi:10.1177/0956797611422237.

Szpunar, Karl K., and Daniel L. Schacter. 2013. “Get Real: Effects of Repeated Simulation and Emotion on the Perceived Plausibility of Future Experiences.” *Journal of Experimental Psychology: General* 142 (2): 323–27. doi:10.1037/a0028877.

Szpunar, Karl K., R. Nathan Spreng, and Daniel L. Schacter. 2014. “A Taxonomy of Prospection: Introducing an Organizational Framework for Future-Oriented Cognition.” *Proceedings of the National Academy of Sciences* 111 (52): 18414–21. doi:10.1073/pnas.1417144111.

Szpunar, Karl K., J. M. Watson, and K. B. McDermott. 2007. “Neural Substrates of Envisioning the Future.” *Proceedings of the National Academy of Sciences* 104 (2): 642–47. doi:10.1073/pnas.0610082104.

Tetlock, Philip, and Dan Gardner. 2016. *Superforecasting: The Art and Science of Prediction*. London, United Kingdom: Random House Books.

Trope, Yaacov, and Nira Liberman. 2003. “Temporal Construal.” *Psychological Review* 110 (3): 403–21. doi:10.1037/0033-295x.110.3.403.

———. 2010. “Construal-Level Theory of Psychological Distance.” *Psychological Review* 117 (2): 440–63. doi:10.1037/a0018963.

Tulving, Endel. 1985. “Memory and Consciousness.” *Canadian Psychology/Psychologie Canadienne* 26 (1): 1–12. doi:10.1037/h0080017.

Ungar, Lyle, Barb Mellors, Ville Satopää, Jon Baron, Phil Tetlock, Jaime Ramos, and Sam Swift. 2012. “The Good Judgment Project: A Large Scale Test of Different Methods of Combining Expert Predictions.” AAAI Technical Report FS-12-06. Association for the Advancement of Artificial Intelligence.

Vermersch, Pierre. 2017. *L’entretien d’explicitation*. 9th ed. Paris, France: ESF Éditeur.

Viard, Armelle, Gaël Chételat, Karine Lebreton, Béatrice Desgranges, Brigitte Landeau, Vincent de La Sayette, Francis Eustache, and Pascale Piolino. 2011. “Mental Time Travel into the Past and the Future in Healthy Aged Adults: An FMRI Study.” *Brain and Cognition* 75 (1): 1–9. doi:10.1016/j.bandc.2010.10.009.

Vito, Stefania de, Antimo Buonocore, Jean-François Bonnefon, and Sergio della Sala. 2015. “Eye Movements Disrupt Episodic Future Thinking.” *Memory* 23 (6): 796–805. doi:10.1080/09658211.2014.927888.

Weinstein, Neil D. 1980. “Unrealistic Optimism about Future Life Events.” *Journal of Personality and Social Psychology,* 806–20. doi:10.1037/0022-3514.39.5.806.

Wickens, Christopher D., Benjamin A. Clegg, Jessica K. Witt, C. A. P. Smith, Nathan Herdener, and Kimberly S. Spahr. 2020. “Model of Variability Estimation: Factors Influencing Human Prediction and Estimation of Variability in Continuous Information.” *Theoretical Issues in Ergonomics Science* 21 (2): 220–38. doi:10.1080/1463922X.2019.1679907.

Wiggins, Mark W. 2014. “Differences in Situation Assessments and Prospective Diagnoses of Simulated Weather Radar Returns amongst Experienced Pilots.” *International Journal of Industrial Ergonomics* 44 (1): 18–23. doi:10.1016/j.ergon.2013.08.006.

Williams, J. Mark G., Nick C. Ellis, Claire Tyers, Helen Healy, Gillian Rose, and Andrew K. Macleod. 1996. “The Specificity of Autobiographical Memory and Imageability of the Future.” *Memory & Cognition* 24 (1): 116–25. doi:10.3758/BF03197278.

Williams, J. Mark G., John D. Teasdale, Zinder V. Segal, and Judith Soulsby. 2000. “Mindfulness-Based Cognitive Therapy Reduces Overgeneral Autobiographical

Memory in Formerly Depressed Patients." *Journal of Abnormal Psychology* 109 (1): 150–55. doi:10.1037//0021-843X.109.1.150.

Zamenopoulos, Theodore, and Katerina Alexiou. 2007. "Towards an Anticipatory View of Design." *Design Studies* 28 (4): 411–36. doi:10.1016/j.destud.2007.04.001.