INSTRUMENTS AS PLAYTHINGS: AN ALTERNATIVE METHODOLOGY FOR THE STUDY OF SCIENTIFIC ARTEFACTS

Abstract: *This article proposes that thinking of scientific instruments as playthings or philosophical toys offers a method for looking at the ways in which we learn from made things and from the act of making in investigating the world. Rather than approaching artefacts as stable objects, definable and categorisable in terms of their function, this method puts forward the instability and mobility of artefacts on several levels: in terms of their movements between hands, social contexts and systems of knowledge, in terms of their physical articulations and of their changing functions, and in terms of the flows and processes of materials at work within and through them.*

Keywords: *historical affordance; scientific playthings; thinking things; variant invariance*

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Přístroje jako hračky: alternativní metodologie výzkumu vědeckých artefaktů

Abstrakt: *Uvažovat o vědeckých přístrojích jako hračkách či filosofických hračkách nabízí specifickou metodu zkoumání způsobů, jimiž se z vytvořených věcí i způsobů jejich vytváření učíme při zkoumání světa. Nepřistupuje k artefaktům jako ke stabilním předmětům, definovatelným a klasifikovatelným na základě jejich funkce, nýbrž zdůrazňuje nestabilitu a mobilitu artefaktů na několika rovinách: jejich pohybu mezi rukama, sociálními kontexty a systémy vědění; jejich fyzické artikulace a proměn funkcí těchto artikulací; materiálních procesů působících v nich i jejich prostřednictvím.*

Klíčová slova: *historická afordance; vědecké hračky; myšlení věci; variantní invariance*

I begin this article by elaborating an understanding of playthings from multi-disciplinary perspectives that consider their role in the reciprocal constitution of self and world. I then explain how the resistant malleability of playthings, their participation in the explorative and expansive play of thought and the attention to technology and materials during play lead a consideration of scientific instruments into the realm of playthings. I use this to argue that regarding instruments as playthings allows for an ecological approach to artefacts that is more concerned with (embodied) comprehension than knowledge and that takes into account their varying roles and meanings. This allows me to introduce the notion of 'historical affordance' to relate the evolution in what an instrument offers to perception, action and understanding. I finally flesh out this methodology and apply it to the Crookes radiometer as a case study to demonstrate how thinking of instruments as playthings offers scope for 'tuning in' to them.

Playthings

In his 1987 presidential address on "Scientific Toys", science historian Gerard L'Estrange Turner describes the importance of *homo ludens* when "considering how human beings acquire knowledge".[1]

> The way in which yesterday's science so often becomes today's recreation does not make it any less scientific. Indeed, much scientific, and other, knowledge is absorbed consciously or unconsciously through play.[2]

Turner's argument is that learning through play has always been essential to "discovering how the natural world works", which is to say scientific understanding, and he illustrates this through an overview of philosophical apparatus and demonstration instruments from the seventeenth and eighteenth century that passed into recreational use in the 19th century and became toys in the twentieth.

In "Cognitive Objects", psychologist Robin A. Hodgkin, similarly concerned with the relationship between scientific discovery and play, tries to work out the nature of this connection.[3] Building on Jean Piaget's

[1] Gerard L'Estrange TURNER, "Presidential Address: 'Scientific Toys'." *British Journal for the History of Science*, vol. 20, 1987, p. 377 (377–398).
[2] TURNER, "Scientific Toys," p. 384.
[3] Robin A. HODGKIN, "Cognitive Objects." *Oxford Review of Education*, vol. 14, 1988, no. 3 (353–362). See also Robin A. HODGKIN, "Making Space for Meaning." *Polanyiana*, vol. 6, 1997, no. 2 (55–71).

framework in developmental psychology and Seymour Papert's theories of cognitive science, he argues that "the key questions" in order to understand this connection

> [...] are not to do with a child's exposure to mechanical ideas in toys, but rather with the many-sidedness and depth of his own involvement in play. Here is the seed bed not only of active science but also of technical craft skills.[4]

The looping structure of play

Hodgkin describes a semi-cyclical and recurrent process of creativity that he visualises as "a looping structure originating in play", which he also uses to show the way in which a plaything oscillates between being toy, tool and symbol; its nature changing as a result of the alternating possibilities of progressing by skill-developing practice on one hand or of proceeding by exploratory "groping and experimenting movements" on the other.[5] His contention is that this cycle is common to all processes of discovery, and that the "cognitive object" or "generative thing-idea" that it involves acts as a "transitional object".[6] This term was introduced by psychologist D. W. Winnicott to refer to a child's first "not-me" possession, which, he contends, enables a mediation between the child's inner and outer world through inhabiting "an intermediate area of experiencing, to which inner reality and external life both contribute", that is by being part of both the subjective and what is objectively perceived.[7] Such objects, according to Winnicott, exemplify the ways in which humans negotiate their relation to the world: their task is to keep inner and outer reality separate but interrelated.[8] Describing archetypes of interaction with "transitional objects" in *Playing and Reality*, he further suggests that "thinking, or fantasying, gets linked up with these functional experiences".[9] This is the insight that Hodgkin picks up on in his

[4] HODGKIN, "Cognitive Objects", p.356. It is important to note that while Hodgkin picks up on the revaluation of concrete reasoning in Piaget, he does not cast it, as the latter does, as an inferior stage in the progression towards formal or abstract thinking: for Hodgkin the two modes of thinking always alternate and, moreover, concrete objects play a significant part in both.
[5] *Ibid.*, p. 357.
[6] *Ibid.*, p. 359.
[7] Donald W. WINNICOTT, *Playing and Reality*. London – New York: Routledge 2008, p. 3.
[8] This also explains how the prospect of the loss of an object is always a part of the love one has for it.
[9] WINNICOTT, *Playing and Reality*, p. 5.

text when he speaks of the "many-sidedness and depth" of involvement in play. Playthings move between the status of tool and symbol, which means that, like transitional objects, they are both sensory and abstract. Playing with things is fundamentally a mediating between material existence and mental operations, a form of search that is essential to science, technology and craft.

While I generally agree with this statement, my concern here is not with the broad relationship between play and science. What I would like to draw on instead are aspects of Hodgkin's description of playthings, which, I will argue, offer a useful tool for thinking of scientific artefacts in a way that takes into account, amongst other things, their varying roles and meanings in a phenomenological/ecological framework. Playthings are objects for thought and action that change their 'nature' in a looping movement, which paradoxically both results from *and* enables a reciprocal and constitutive interaction between self and world. A plaything, rather than being defined by a function, embraces varying roles, switches in the categories that it belongs to and is even prone to changes in what constitutes it, all the while still remaining, in some sense, itself. How does this varying invariance operate? What kind of understanding does it present? What kind of engagement does it require? How does it involve the thing that it puts into play?

Familiar and poetic substance

In a short essay on "Toys" in his *Mythologies*, literary theorist Roland Barthes laments complicated "French toys" with which a child can only engage as a user or owner, and opposes them to simple playthings, such a set of blocks, which provide "a very different kind of learning".[10] With these "unrefined" playthings,

> [...] the child does not in any way create meaningful objects, it matters little to him whether they have an adult name; the actions he performs are not those of a user but those of a demiurge. He creates forms which walk, which roll, he creates life, not property: objects now act by themselves, they are no longer an inert and complicated material in his hand.[11]

[10] Roland BARTHES, "Toys." In: Roland BARTHES, *Mythologies*. Translated by Annette Lavers. London: Vintage 2000, p. 54 (53–55).
[11] *Ibid*., p. 54.

In describing playthings coming to life in this way, Barthes is not implying an animistic understanding of toys, but rather identifying a particular kind of contact with the world – one that they offer in the shape of an object which both yields to the player's desires and whims and at the same time informs them. These playthings provide what he describes as "a familiar and poetic substance", something simple that can be deployed intricately and that keeps child and environment in close contact.[12] When built using "an ideal material", such as wood for instance, they "can last a long time, live with the child, alter little by little the relations between the object and hand".[13] It is an attentive and caring relationship that evokes the emotional attachment to "transitional objects" and that likewise develops a sensitive and enquiring approach to the world. It is moreover an immersive experience that understands the need for taking one's time, for putting time into things. The movement it entails, as Hodgkin has suggested, is a loop rather than a straight line: its objective is not to complete a journey or to get somewhere, but rather to cover as much space as it can while retracing itself, to spread out. It is, in that sense, spatial, whence both Hodgkin and Winnicott's reference to an intermediate *space* or privileged *zone* of play. Like the loop, it recursively goes back and forth without crossing over itself, is concerned with versatility rather than economy and has for principle an extension of possibilities, a spread in testing them out. The actions it involves are "those of a demiurge", because they are a kind of composition, a creative act that plays out the different possibilities of the thing put into play. Playing with a thing is a playing out of its affordances, and the ideal plaything offers a wide range of affordance, has a lot of "play".

Thinking things

In "A Philosophy of Fidgets", cultural theorist Steven Connor reflects on the things that seem to call for such looping actions and suggests that they might embody thinking, make it palpable:

> The deeper secret of these objects is perhaps that they are the necessary accessories to thought. Perhaps they are forms of thought themselves. [...] It is as though we were compelled to act out literally the meaning of the word 'reflection', from *re-flectare* to bend back on oneself. Just as we recruit our own bodies

[12] *Ibid.*
[13] *Ibid.*

> for these doubling enactments of our own reflective work, so we requisition objects to join the flexing play of thought.[14]

Connor describes such playthings as "accentuating rather than accelerating devices", as instruments "for pervading rather than progress".[15] They are necessary for thought because they give shape to the operations of thinking, they offer thinking an external object with which to think of itself. They are what he calls 'thinking things', "the kinds of thing that draw, drain and detain our thinking, and that make thinking accessible as a kind of thing":[16]

> [T]hinking as an adjectival participle and thinking as the name of an action – thus 'things that are thinking' and 'thinking about things'. [...] So thinking things constitute a surrogate way of thinking about the things that thinking takes to itself in order to think about the way it thinks about things…[17]

"Thinking things" are the things with which we interrogate both the world and our thinking about the world, they are the things *of*, *through* and *in* which we think the world. Playthings are what we think *of* in the absorption and intent that playing with them requires. They are what we think *through* when we enrol them in our exploratory activities. They are what we think *within* when they come to stand for the thinking about the world that is thought *through* them as an extension of us into the world and *of* them as a part of the world exterior to us. The plaything, then, shares its play loop with "the flexing play of thought": both join in this flickering between thing and thought, between object and subject, that reciprocally constitutes them both.[18]

[14] Steven CONNOR, *A Philosophy of Fidgets* [online], talk given at the Liverpool Biennial *Touched* Talks, 17 Feb 2010. 2010. Available at: <http://www.stevenconnor.com/fidgets/> [cit. 15. 7. 2013], p. 3.
[15] *Ibid*., pp. 4–5.
[16] Steven CONNOR, *Thinking Things* [online], plenary lecture given at ESSE-9, the 9th annual conference of the European Society for the Study of English (ESSE), Aarhus, Denmark, 25 August 2008 and as the Textual Practice lecture, University of Sussex, 14 October 2009. 2008–2009. Available at: <http://www.stevenconnor.com/thinkingthings/> [cit. 15. 7. 2013], p. 4.
[17] *Ibid*., p. 22.
[18] CONNOR, "A Philosophy of Fidgets," p. 3.

Evocative objects

This reciprocal constitution of subject and object in play is what motivates essayist Walter Benjamin to call for a "philosophical classification of toys" that would "penetrate to the reality [and] to the conceptual understanding of toys" in several essays on playthings and on "the mysteries of the world of play" into which they lead:[19]

> We experiment early on with basic rhythms that proclaim themselves in their simplest forms in these sorts of games with inanimate objects. Or rather, these are the rhythms in which we first gain possession of ourselves.[20]

Playthings are what sociologist of science Sherry Turkle calls "evocative objects" to emphasise "the inseparability of thought and feeling in our relationship to things". As she puts it, "[w]e think with the objects we love; we love the objects we think with".[21] As both affective companions and "provocations to thought", playthings are at the origin of the "basic rhythms" through which our emotional and intellectual lives are composed.[22] The question then is: how does this work? What makes playthings evocative?

In "The Cultural History of Toys", Benjamin cautions against the common "assumption that the imaginative content of a child's toys is what determines his playing; whereas in reality the opposite is true."[23]

> A child wants to pull something, and so he becomes a horse; he wants to play with sand, and so he turns into a baker; he wants to hide, and so he turns into a robber or policeman.[24]

Here are again the "actions of a demiurge", the creative acts that put things into play; but Benjamin's description reveals an additional and important aspect of this enrolling of things: it is specific to what each thing offers to be

[19] Walter BENJAMIN, "The Cultural History of Toys." In: JENNINGS, M. W. – BULLOCK, M. – EILAND, H. – SMITH, G. (eds.), *Walter Benjamin: Selected Writings, Vol.2, Part 2, 1927-1930*. Cambridge – London, Belknap Press 2005, pp. 115–116 (113–116). See also Walter BENJAMIN, "Old Toys: The Toy Exhibition at the Märkisches Museum." In: *Walter Benjamin: Selected Writings*, pp. 98–112.
[20] Walter BENJAMIN, "Toys and Play: Marginal Notes on a Monumental Work." In: *Walter Benjamin Selected Writings*, p. 120 (117–121).
[21] Sherry TURKLE, "Introduction: The Things That Matter." In: TURKLE, S. (ed.), *Evocative Objects: Things We Think With*. Cambridge, MA: MIT Press 2007, p. 5 (3–10).
[22] *Ibid*.
[23] BENJAMIN, "The Cultural History Of Toys," p. 115.
[24] *Ibid*., p. 115.

done with it, to its affordance. The child does indeed determine the imaginative content of a plaything, but she does so in recognition of and in reaction to the possibilities for action that the plaything presents to her. A toy carriage is pull-able, and in pulling it the child may imagine herself a horse drawing the carriage; sand can be wet into doughy mud and be kneaded, allowing the child to impersonate a baker; but it can also be poured and have her picture herself an hourglass, or be used to build sandcastles making her a kind of architect. It cannot, however, be pulled, or tied, or folded. The imaginative content of playthings is determined by the child but, it also always results of the affordances of the thing for the child: it is part of a particular moment or circumstance and is linked to a desire or query, to something someone wants to do that it presents itself as useful for. This can range from wanting "to pull something", through testing what can be done something and what purposes it can serve, to looking to represent something, or most typically an intermingled combination of several of these.

Ecology and the theory of affordance

The way in which the perception of things is situated and they way in which they are apprehended as possibility for action are the founding principles of James J. Gibson's ecological approach to perception and of his theory of affordance that the methodology I am proposing builds on. In *Ecological Approach to Visual Perception*, Gibson introduces his ecological understanding of the environment as what affords animate life, that is, as what supports perception and behaviour, which are in turn reciprocally related to the ecosystem.[25] He explains his understanding of ecological reality thus:

> The world of physical reality does not consist of meaningful things. The world of ecological reality, as I have been trying to describe it, does. If what we perceived were the entities of physics and mathematics, meanings would have to be imposed on them. But if what we perceive are the entities of environmental science, their meanings can be *discovered*.[26]

Gibson's ecological theory describes things in terms of their organism-indexed significance in relation to living forms as well as in terms of their ecological (shared) objectivity, both of which are understood to be in dis-

[25] James J. GIBSON, *The Ecological Approach to Visual Perception*. New Jersey – London: Lawrence Erlbaum Associates 1979.
[26] *Ibid*., p. 33.

continuous and reciprocal (animal-environment) change. Based on this understanding, he elaborates the theory of "affordances", a term he uses to describes "what [the environment] offers animals, what it provides or furnishes, for good or ill", that is, any opportunity or danger within an organism's environment.[27] He further insists that an affordance is neither a subjective nor an objective property or "could be both" and that it "points both ways, to the environment and to the observer".[28] Things, then, have affordances defined by the possibilities for action on a particular environment. This can be thought of as "-ables' as in "movable", "see-through-able", "touchable", "smell-able", "sit-upon-able etc". [29] Affordances are, moreover, perceived in relation to the organism in question: different things afford different meanings and actions to different organisms.[30] Gibson finally notes that, rather than qualities or properties say, affordances are always what we first pay attention to in things.[31]

Following Gibson's ecological framework, affordances, availability, access and the particulars of a given situation play an essential part in the enrolment of a thing in enquiring play. It nevertheless seems that some objects are more evocative than others, that some things are better at leading into "real living play".[32] So what then has the affordance of an ideal plaything? What possesses the resistant malleability required for the exploratory looping of play? What constitutes, in Barthes' words, a "familiar poetic substance" and is that demanded from a plaything?

Clarity of materials and technology

Like Barthes, Benjamin bemoans complex toys and those "based on imitation", which he says lead away from authentic playthings and from "real

[27] James J. GIBSON, "The Theory of Affordances." In: SHAW, R. – BRAUSFORD, J. (eds.), *Perceiving, Acting and Knowing: Toward an Ecological Psychology*. New York – Toronto – London – Sydney: John Wiley & Sons 1977, p. 68 (67–82).
[28] GIBSON, *The Ecological Approach*, p. 129.
[29] M. T. TURVEY, "Perception: The Ecological Approach." In: NADEL, L. (ed.) *Encyclopedia of Cognitive Science*. London: Nature Publishing Group 2002, p. 540 (538–541). See also draft article Claudia CARELLO and M. T. TURVEY, *The Ecological Approach to Perception* [online]. Available at: <ione.psy.uconn.edu/~corr/EncCogSci.pdf> [cit. 14. 8. 2013].
[30] GIBSON, "The Theory of Affordances," p. 79.
[31] GIBSON, *The Ecological Approach*, p. 75.
[32] BENJAMIN, "The Cultural History of Toys," p. 116.

living play".[33] Noting how "chaste" children are in their use of materials and how interested they are in the construction and modification of toys in play, he proposes that a "particular clarity" is required that makes genuine playthings:[34]

> In the case of toys simplicity is to be found not in their shapes but in the transparent nature of the manufacturing process. Hence, it cannot be judged according to an abstract canon but differs in different places, and is less a matter of formal criteria, because a number of methods of processing – carving, in particular – can give free rein to their imagination without becoming in the least incomprehensible. In the same way, the genuine and self-evident simplicity of toys was a matter of technology not formalist consideration.[35]

Benjamin, like Barthes, insists that: "however unified and unambiguous the material is, the more it seems to embrace the possibility of a multitude of figures of the most varied sort".[36] But he suggests that the required simplicity is not only to be found in an object's material composition: technological transparency is also essential. Structure and operation must, like materials, be accessible and intimately grasped in order for them to be effectively deployed. It is the clarity of the processes at work in an object that determine its simplicity and its consequent creative potential both practically and allegorically. In the same way that we can only use words to their full poetic or theoretical potential once we've become familiar with the way they work, so can we only put artefacts maximally to play when their technology is "self-evident" to us.

Benjamin, also like Barthes, seems to be giving primacy to wood as a material, but his reason for that is not something to do with an inherent quality of the substance: it is rather to do with the "methods of processing" that it lends itself to, the particular comprehensibility of carving as a method of making. A genuine plaything necessitates an intimate understanding of its inner workings by the person engaging with it. While it is easy for most people to agree with Benjamin that carving is in that sense particularly easy to understand, perhaps we should keep in mind that comprehension is in the eye of the beholder. A technology that seems alien to a person might be

[33] *Ibid.*, pp.115–6. He writes that "imitation [...] is at home in the playing, not in the plaything," p. 116.
[34] BENJAMIN, "Toys and Play," p. 119.
[35] *Ibid.*, p.119.
[36] BENJAMIN, "The Cultural History of Toys," p. 115.

another's favoured plaything; a medium that seems opaque to a person could open up a world of possibilities to another.

Skill

This account of playthings puts forward the way in which making things and interacting with them are interrelated rather than opposed practices, and the fact that both are based on an attentive engagement of human beings with elements of their environment.

Artefacts are *made* things and should be thought of as the outcome of the skilful engagement of a maker with elements from his or her environment. In a chapter from *The Perception of the Environment* in which he discusses skill and the construction of artefacts, anthropologist Tim Ingold insists on the importance of doing away with the modern dichotomy between art and technology that separates made things in terms of oppositions between mental/material or semiotics/mechanics, and presents the notion of "skill" as a solution to this split.[37] To describe what he means by "skill", Ingold articulates five critical dimensions of skilled practice: the first is that intentionality and functionality are immanent in it as a synergetic process involving humans, tools and materials rather than being an attribute of one or the other; the second is that it is an ecologically embedded system of relations between the body and the environment; the third is that it is grounded in an attentive perceptual involvement with things requiring care and a haptic dexterity based on a "continual adjustment or "tuning" of movements in response to an ongoing monitoring of the emergent task"; the fourth is that it is handed down practically "by introducing novices into contexts which afford selected opportunities for perception and action, and by providing the scaffolding that enables them to make use of these affordances"; the fifth, related to Ingold's claim that "what we call 'things' too are grown", is that skilled practice precedes design in generating the form of artefacts.[38]

I think that by describing "the transparent nature of the manufacturing process" that makes for an ideal plaything, Benjamin is referring to artefacts

[37] Tim INGOLD, *The Perception of the Environment: Essays in Livelihood, Dwelling and Skill*. London: Taylor & Francis Inc. 2000.

[38] INGOLD, *The Perception of the Environment*, p. 345; p. 345; p. 83. See also Tim INGOLD, "Making Culture and Weaving the World." In: GRAVES-BROWN, P. M. (ed.) *Matter, Materiality and Modern Culture*. London – New York: Routledge 2000 (50–71) where he argues we should think of making "as a modality of weaving" [p. 54], meaning that in making "we work from within the world, not upon it" [p. 68].

where the five dimensions of skill articulated by Ingold are visible, that is objects that clearly present the affordances involved in making them as an essential part of those offered in interacting with them – this is the "clarity" that makes something a thing for "real living play".

As components of an ecological environment that unfolds, rather than of a physical/material world that just is, these properties of things, as Ingold puts it, "occur", meaning that they are "processual and relational", that they are "neither objectively determined nor subjectively imagined, but practically experienced".[39] As such, they emerge through a reciprocal and changing engagement between being and environment, which is what leads Ingold to the conclusion that "[t]he properties of materials, in short, are not attributes, but histories".[40]

Destruction

I will elaborate on the necessity of a historical dimension when considering instruments as playthings when I flesh out the principles of the methodology that I am proposing below. Before that however, I would like to address another aspect of the investigative tendency in play that is less concerned with arrangement and composition, a way at getting to the inner workings of a thing in which testing its affordances is pushed to its extreme, where the object is taken to its limit – its destruction. As Connor writes,

> perhaps all play has at its horizon the death of the plaything. When we put something to work, we use it for a particular purpose. In play, we seek not so much to use them as to *use them up*. The point of putting things into play may be to play them out, to see how far they go, how far we can go with the open totality of their affordances.[41]

In "A Philosophy of Toys", the poet and essayist Charles Baudelaire, examining the role of playthings "in the great drama of life", considers the tendency to take them apart.[42] Like Barthes and Benjamin, he begins his essay by describing the genial affordance of things in play, citing the example

[39] Tim INGOLD, "Materials against Materiality." In: Tim INGOLD, *Being Alive: Essays on Movement, Knowledge and Description*. Oxon – New York: Routledge 2011, p. 30 (19–32).
[40] *Ibid*., p. 32.
[41] CONNOR, "A Philosophy of Fidgets," p. 3.
[42] Charles BAUDELAIRE, "A Philosophy of Toys." In: Charles BAUDELAIRE, *The Painter of Modern Life and other Essays*. Translated by Jonathan Mayne. London: Phaidon Press 1964, p. 198 (197–203). For further examples of the affordance of playthings see also Charles

of a simple chair that becomes at once carriage, horses and passengers in a game of *diligence*.[43] Baudelaire also underlines the creativity involved in such play, the "poetry of childhood" that unfolds when engaging with "these little inventions".[44] This even has him place playthings at the origin of aesthetic sensibility: "the toy", he writes, "is the child's first initiation to art".[45]

However, for Baudelaire, the "overriding desire" when putting things to play, the principal affordance of playthings, is the opportunity to dismantle them, to dissect them, to break them open in order to "get at and *see [their] soul*".[46] He illustrates this testing of a plaything to destruction, and the "extraordinary agility and strength" applied at it:

> The child twists and turns his toy, scratches it, shakes it, bumps it against the walls, throws it on the ground. From time to time he makes it re-start its mechanical motions, sometimes in the opposite direction. Its marvellous life comes to a stop. The child, like the people besieging the Tuileries, makes a supreme effort; at last he opens it up, he is stronger. But *where is the soul?* This is the beginning of melancholy and gloom.[47]

Baudelaire sees in this impulse to play things out "a first metaphysical tendency", a search concerned with the nature of existence for, as he put it at the text's opening, "is not the whole life to be found [in playthings]?"[48] While the answer to this at first seemed affirmative, it now appears to be "no". Or perhaps Baudelaire is suggesting that things are not that simple, that in a sense all of life it is in playthings yet at the same time not really there at all.

Allegorical objects

It is this paradox that literary theorist Daniel Tiffany picks up on in *Toy Medium* in which he describes the ambivalent matter of playthings, how they are always more and less than what they take themselves to be.[49] He points

BAUDELAIRE, "The Plaything of the Poor." In: SMITH, T. R. (ed.) *Baudelaire: His Prose and Poetry*. New York: Boni & Liveright Inc. 1919 (70–71).
[43] *Ibid*., pp. 198–199.
[44] *Ibid*,. p. 200.
[45] *Ibid*,. p. 199.
[46] *Ibid*,. p. 202.
[47] *Ibid*,. pp. 202–203.
[48] *Ibid*,. p. 202.
[49] Daniel TIFFANY, *Toy Medium: Materialism and Modern Lyric*. Berkley: University of California Press 2000.

out how the plaything in Baudelaire's text is "*antithetical*, at once philosophical and inimical to reflection, ideal and concrete".[50] The impulse to open up the plaything in the destructive narrative above is in fact evidence of the "metaphysical" world that it represents for the child, the idea of "material things founded on the immateriality of 'the soul' – the allegorical object, in effect".[51] Rather than the "melancholy and gloom" that the spleen-ridden Baudelaire sees in the failure at finding a soul in the plaything, Tiffany argues that it registers the beginning of allegorical thinking: playthings are our first models for our understanding of the world, they are exemplary of the objects we use as structural substitutes in natural philosophical investigations to make the intangible tangible. As Tiffany puts it,

> Inquiries into the nature of material substance rely fundamentally on images that do not bear witness to empirical entities, but rather serve as models of unobservable phenomena. Indeed, the *realism* of modern physics (in contrast to its mathematical foundation) relies, by necessity, on a framework of vivid analogies and tropes, sometimes realized in visual practice. That is to say, the foundation of material substance is intelligible to us, and therefore appears to be real, only if we credit the imaginary pictures we have composed of it.[52]

Tiffany's book is concerned with how poetry "can help to elucidate the sometimes paradoxical bodies conjured by scientific materialism"; and an exploration of playthings winds through his inquiry because the toy, he argues, is the fundamental manifestation of the paradoxical thing suspended between matter and immateriality, "a spectacular device that discloses, in the name of science, the immaterial foundation of the object – the invisibility of the real".[53] In his narrative, playthings represent the "hypothetical modelling of invisible matter", which leads him to write that "[t]he toy divines the invisible substance of things".[54]

When breaking the plaything open to look for its interior mechanism and finding no "soul" in it, we learn that our natural investigations can only yield an imagined interior of things; which is why the plaything, as well as being an abbreviation of the whole world, is the perfect symbol of the methods with which we investigate the world. Perhaps this is the reasoning that

[50] TIFFANY, *Toy Medium*, p. 307, note 21.
[51] *Ibid*,. p. 73.
[52] *Ibid*,. p. 3.
[53] *Ibid*,. p. 6; p. 82.
[54] *Ibid*,. p. 52.

has Benjamin conclude his article by saying: "If a modern poet maintains that for each individual there exists an image which engulfs the world, how often does that image not arise from an old toy chest?"[55]

Even testing playthings to their destruction is in a sense constructive to understanding: when they break, playthings simply go from being things with which we understand the world to becoming things with we understand our ways of understanding the world with things – "thinking things" with which we interrogate our thinking about the world.

But breaking playthings open is also practically useful in the quest to understanding them as artefacts, as *made* things: it reveals how they are constituted, not only in terms of material parts, but also, as Benjamin suggests, in terms of the technologies that form them and make them work, which it to say, as Ingold shows, the different dimensions of skill involved in their making, the combined movements of people, materials and tools that bring them to be. When a thing stops to work or is broken open, these movements are made visible through the formation of an understanding of what causes the thing to fail or break. In this sense, breaking a plaything is only part of putting it to play with all the search and learning that such play involves.

Playthings methodology

The methodology I am proposing is concerned with the material culture of natural philosophy and science, specifically with the ways in which we learn from made things and from the act of making in investigating the world. Rather than the "knowledge" we get from instruments, with all the epistemological baggage of truth, justification and objectivity that the term entails, it addresses something closer to the word "comprehension" which finds its Latin etymological root (*comprehend-ĕre)* in the act of grasping at something before actually seizing or comprising it, and the word "understanding" with its source in the German for "to step under" (*understân)* or "to take upon oneself" (*unterstehen),* with the embodied engagement with the world

[55] This quote is from Benjamin's "Toys and Play" referenced above, but I am using here Tiffany's translation in *Toy Medium* [p. 81] which, by using the word "engulf" to translate from the German "versinkt", I find closer to the original text: "Wenn aber ein moderner Dichter sagt, es gebe für jeden ein Bild, über dem die ganze Welt ihm versinkt, wie vielen steigt es nicht aus einer alten Spielzeugschachtel auf?" from Walter BENJAMIN, "Spielzeug und Spielen." In: TIEDEMANN-BARTELS, H. (ed.) *Gesammelte Schriften*, vol. 3. Frankfurt: Suhrkamp Verlag 1972, p. 131.

that such actions would involve.[56] My suggestion is that regarding scientific instruments as playthings would allow for a multi-faceted approach to their role in the co-constitution of human perception and understanding of the world.

Following the elaboration on playthings above, let us go through the ways in which the analogy is fruitful for these aims by applying them to the Crookes radiometer as a case study.

The Crookes radiometer

The most common form for a Crookes radiometer (or light-mill) consists of a glass bulb of about 10 cm in diameter, mounted on a stand. It is partially evacuated and contains an anemometer-like structure of four vanes pivoted on a vertical axis. These vanes are usually white on one side and black on the other, and all face the same way. When the instrument is exposed to light, this "fly" rotates with the white sides leading, its spin intensifying with the length of exposure, and slowing down then stopping when the light source is taken away.[57]

In an article published on the centennial of the instrument's inception, historian Clifton W. Draper makes a case for the importance in science education of the device that has "fallen to the unprestigious role of a gift shop knickknack".[58] Besides the fact that its theory "is today still only qualitatively understood", his reasons include the interest of its inventor William Crookes' life and career, its history's wealth in "accidental observations, lengthy and ingenious experimentation, and incorrect conclusion all leading to a not totally satisfying theory" and the ease with which it lends itself to experiments adaptable to different audiences rendering it a very useful classroom tool.[59] Draper's arguments for giving attention to the Crookes radiometer show the breadth of play of the device and explain its particular suitability for the "playthinging" that I am putting forward in this article.

[56] "[comprehend, v.]" in: *Oxford English Dictionary* [online]. Second edition, 1989. 2012. Available at: <http://www.oed.com/view/Entry/37847> [cit. 7. 8. 2012]; "[understand, v.]" in: *Oxford English Dictionary* [online]. Second edition, 1989. 2012. Available at: <http://www.oed.com/view/Entry/212085> [cit. 7. 8. 2012].

[57] Crookes names the moving part this way first in William CROOKES, "On Repulsion Resulting from Radiation – Parts III. & IV." *Philosophical Transactions of the Royal Society of London*, vol. 166, 1876, p. 344 (325–376). See image 1.

[58] Clifton W. DRAPER, "The Crookes Radiometer Revisited: A Centennial Celebration." *Journal of Chemical Eductaion*, vol. 53, 1976, no. 6, p. 356 (356–357).

[59] *Ibid*., p. 356.

Although I believe that the aspects that will be teased out through regarding a device as a plaything are true of all artefacts, some devices, for non-noumenal reasons, seem to show them in an extended way: they seem to be made to be transformed and seem particularly prone to fall in the gaps of classification systems, to require and register paradigm shifts that they outlive. The radiometer falls into this category, and that probably explains why it became a toy and is still widely available today.

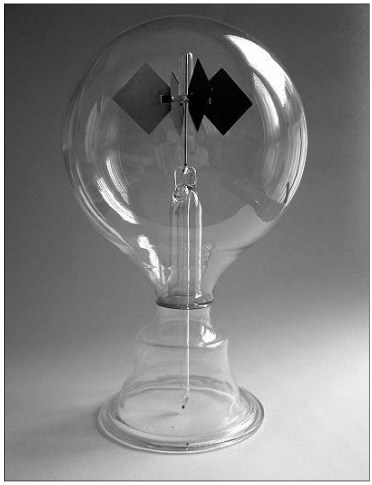

Image 1: *"Crookes Radiometer," Image by Timeline for* Wikipedia Commons *[online] 2005. Available at: <http://en.wikipedia.org/wiki/File:Crookes_radiometer.jpg> [cit. 2. 9. 2012].*

A good standard description of the device explains that, despite its name, it is a demonstration device rather than a measuring instrument, relates the way in which it grew out of its inventor's recognition of an anomaly when weighing hot samples in vacuum, tells how its theory caused controversy from the time it was first presented in 1874 and how its operation is still considered complicated to this day, recounts some of the big names of science whose interest it attracted, describes the way in which Crookes' investigation of its effects took him in a different direction (generally described as erroneous) to his contemporaries and usually lists

the device's contributions to the kinetic theory of gases and to the invention of the cathode ray tube.[60]

Such an account certainly points out the fascinating story of the device but, I would argue, does not capture the array of understanding that the device offers as a material object, the variation in its affordance to action and perception, which is to say its "play". Thinking of it as plaything however, as I will demonstrate below, leads to a more comprehensive account in these respects.

Restoring mobility

A plaything, as we've seen in Hodgkin's account above, is recognised as such through the part it performs in the looping structure of play. It is a material object in constant oscillation along this loop, its nature varying in a recurrent semi-cycle. It seamlessly moves between the status of tool, toy and symbol, is both sensory and abstract and, rather than being defined by its function, embraces change in its role, constitution and classification all the while still remaining itself. Considering a scientific instrument as a plaything means, in the first place, restoring its inherent mobility as an artefact.

Rather than defining the instrument in terms of its function, it means opening it up to the various uses it has been put to, as well to others it might in the future be applied for, whether scientific or not because all thoughtful engagements produce understanding.

In the case of the radiometer, this means that rather than defining it as a demonstration instrument, which creates a phenomenon and provides working knowledge of it, we can also address its inventor's intended function of it as a measuring instrument for radiation (whence its appellation radio*meter*), regardless of it fulfilling this function. It also allows us to look into the way it was hypothesised as a model: for action at a distance in Crookes's first interpretation of its behaviour as well as (a not particularly effective one) for the kinetic theory of gases in the accepted explanation of its workings. It gives us access to the tacit know-how informed by its construction as perfected by Crookes and his assistant Charles Gimmingham, as well as to the objective information it offers that passes into the domain of scientific

[60] Excellent examples of such an account are two articles by Norman R. HECKENBERG, "Radiometer, Crookes." In: BUD, R. – WARNER, D. J. (eds.), *Instruments of Science: An Historical Encyclopedia*. London – New York: Science Museum & Smithsonian 1998, pp. 510–511; and Norman R. HECKENBERG, "Crookes' Radiometer and Otheoscope." *Bulletin of the Scientific Instrument Society*, no. 50, 1996, pp. 40–42.

and technological knowledge proper. It also admits the subjective understanding it has offered at various times, including its relevance to Crookes' spiritualist investigations into medium communication. In other words, considering the radiometer a plaything challenges the divisions, definitions and categorisations that would limit what is admitted as understanding in what the device has to offer.

Sensitive and enquiring process

In 1873, Crookes was attempting to determine the atomic weight of Thallium, the new element that he had discovered by use of the spectroscope. It was during these "very laborious researches" that he noted the odd behaviour of the warm samples that he was weighing in an evacuated chamber, and it was this recognition of an anomaly and the desire to stabilise its effect that lead to the making of the radiometer.

Noticing that something is behaving anomalously presupposes a tacit knowledge of the context in which a phenomenon is encountered, that is an attentive sensitivity to the usual workings of a defined environment. It results from directed chance, borne out of a more or less defined course of investigation and necessitating skill and training in order to recognise the significance of the chance encounter; in this case, the anomalous behaviour of heated bodies in vacuum. In *Representing and Intervening*, philosopher of science Ian Hacking suggests that even the most irrational looking course of inquiry can be a tool of discovery. To the question: "must there be a conjecture under test in order for an experiment to make sense?" he answers: "I think not."[61] What is however required are attentiveness, care and practice, which provide the means of understanding and interpreting the effects produced. It is important that Crookes was aware of how things were meant to behave according to the scientific theories of the time and through his experimental experience. Had this not been the case, he would not have distinguished the phenomenon as anomalous. It is also essential that he recognised its meaningful potential. Without this informed curiosity, experimentation would not have taken place. The recognition of an anomaly in his study of Thallium led Crookes to look at ways of elaborating the striking effect that he believed would be of scientific significance.

[61] Ian HACKING, *Representing and Intervening: Introductory Topics in the Philosophy of Natural Science*. Cambridge – New York – Melbourne: Cambridge University Press, 1983, p. 154.

This inductive process and its various contingencies are brought to the fore when one considers the device as a plaything: the sensitive and enquiring approach to the world that it entails is put forward, suggesting a hands-on and groping approach to understanding, the more embodied and immersed aspect of scientific inductive reasoning. To the enduring philosophical question of whether it is theory or practice that comes first in scientific inquiry, the answer this method presents is an oscillation between the two, a reciprocal constitution of one through the other.

It also brings out the spatial nature of this kind of engagement when all paths are still possible and various options are tested; and helps identify the particular context for this searching activity, an experimental space which, like the privileged zone of play, has its own laws and is in a way extracted from everyday rules. Instruments in the making are like playthings as the things we think *of* in the absorption and open-ended intent that "playing" with them requires.

Evocative objects: things we think with

Instruments are evocative objects for their makers and users. In the case of the radiometer, this is made particularly clear through its inventor adopting the instrument as a symbol for his scientific researches and achievements. When the scientist was knighted in 1897, the most prominent icon in the design of his coat of arms (pictured below, image 2) is a depiction of the radiometer. His chosen motto inscribed on a scroll underneath it is "Ubi crux ibi lux," which translates into: "Where the cross is, there is light." Although this line most obviously refers to the Maltese cross on his cathode ray which features twice at the upper corners of the design, his biographer William H. Brock also reads it as wordplay by the inventor: "Where Crookes is, there is light" – the light of knowledge provided by the radiometer, its whirling vanes representing "the black of scientific ignorance fleeing from the white of a new understanding of fundamental physics."[62]

A 1902 portrait of Crookes holding the radiometer firmly in his left hand while his right hand rests casually in his pocket further demonstrates the symbolic importance of the radiometer for its inventor (see image 3). The fact that he chose to be represented with the device in his hand two decades after he first presented it is significant. The image reveals something

[62] William H. BROCK, *William Crookes (1832–1919) and the Commercialisation of Science*. London: Ashgate 2008, p. 222.

of the relationship between the instrument and its maker: Crookes seems confident in his handling of the object held up like a sword. It is the weapon that renders the world knowable and controllable by science, and it becomes an extension of the scientist's body, assimilated by his everyday practice. Scientist and instrument appear bound in a seamless way by a narrative of knowledge and intellectual ascendance. In this narrative, the radiometer plays the part of the key to understanding the world.

Image 2 (left): *"Sir William Crookes (1832–1919)" in* Escutcheons of Science – Armorial of Scientists – Numericana *[online]. Available at: <http://www.numericana.com/arms/crookes.htm> [cit. 28. 6. 2009].*

Image 3 (right): *"Sir William Crookes (1832–1919)" from* Vanity Fair*, 1902, by "Spy" Sir Leslie WARD (1851–1922) [online]. Available at: <http://commons.wikimedia.org/wiki/File:Sir_William_Crookes_1902.jpg> [cit. 16. 5. 2009].*

A tiny otheoscope mounted on a tiepin that Crookes is said to have always worn plays a similar symbolic role. I found a reference to it in a letter to his son where he introduces this new variant of the radiometer under the first name he had given it, "elaunoscope", writing: "I have one about

½ inch in diameter mounted as a scarf pin."[63] I believe it is this accessory that I photographed in a small case at Blythe House (below, images 4 and 5). It can now be found in a case near the entrance of Royal Society's Library in Carlton Terrace, London, along with most of Crookes' radiometers, which he presented to the Royal Society in 1911.

Images 4 and 5: Photographs taken by the author at the Science Museum's storage facility in Blythe House in April 2009.

Recognition of and reaction to affordances

As with playthings, what makes an instrument evocative is a result of the recognition of and reaction to the possibilities of action that it presents to its maker as well as to its users. They result from the affordances of an object and/or environment to a scientist that appear useful to his or her investigative purposes. The "actions of a demiurge" that lead to their making

[63] William CROOKES, "Letter to Henry," quoted in E. E. FOURNIER D'ALBE, *The Life of Sir William Crookes*. London: T. Fisher Unwin Ltd. 1923, p. 261.

consist of testing out, modelling with, and refining materials and phenomena in particular circumstances for which they present themselves as useful. What an instrument offers to be done with it, as with a plaything, cannot be thought of as separate from the process of making it, from the skilled practice involving materials and techniques that leads to its emergence.

In "Showing, Doing and the Ontology of Using Scientific Instruments", philosopher of science Denis L. Sepper proposes the following description for how an artefact becomes a scientific instrument:[64]

> I would suggest that as a general principle that objects become scientific instruments (or perhaps proto-instruments) when they display an effect of interest to researchers, i.e., within an already well-defined context of investigation. [...] If the effect is sufficiently striking and if one also discovers that one can elaborate the effect and even do things with it, the object becomes a full-fledged processing instrument.[65]

Sepper further notes that the transformation of an object into a processing instrument affects the instrumental significance of related objects and opens up the possibility of developing new compound and more complex instruments.[66]

Scientific instruments, then, come to be or, more accurately, are made, within particular contexts of investigation through their association with particular effects that are enrolled for action and interpretation in these contexts and that can subsequently extend beyond them. Thinking of instruments as playthings brings these contexts, effects and negotiations to the fore. In that sense, it helps unravel what is referred to as "black-boxing" in the sociology of science: rather than considering instruments as input-output devices that unproblematically transmit natural knowledge, it facilitates the aims of constructive approaches to the history of science which address scientific practices and socio-political and cultural contexts in order to unravel the social means through which particular experiments executed

[64] Dennis L. SEPPER, "Showing, Doing and the Ontology of Using Scientific Instruments." In: DRAGONI, G. – McCONNELL, A. – TURNER, G. L'E. (eds.), *Proceedings of the Eleventh International Scientific Instrument Symposium* [Bologna University, 9–14 September, 1991]. Bologna: Grafis Edizioni, 1994 (29–34).
[65] *Ibid.*, p. 30.
[66] *Ibid.*, pp. 31–32.

by specific experimenters with specific instruments came to produce valid knowledge for particular audiences.[67]

Reverse black-boxing

In the case of the radiometer, this allows an elaboration on Crookes and Gimmingham's experimental work towards stabilising the observed effects of repulsion resulting from radiation into an instrument "which had none of [the] defects [of previous arrangements], whilst it showed the movement of rotation in a very convenient matter".[68] It also allows for a discussion of the scientific context in which the device was presented, the controversy it caused in the interpretation of its effects, the various players involved in its scientific career and its eventual epistemic obsolescence. While the radiometer first caused sensation in the scientific community when it was presented at a Soirée of the Royal Society on April 7th 1875, especially because of its promise of answers about the nature of light and radiation, critics of Crookes theory of its behaviour were quick to emerge. His positing of a pressure of radiation causing the vanes to rotate was criticised by Osborne Reynolds who convincingly argued that the movement of the radiometers' vanes could be easily explained by the presence of residual gas in the evacuated chamber.[69] Reynolds further referred to an experiment by Arthur Schuster, led at his instigation, which gave experimental evidence that "the Force which turns the Mill is not directly referable to Radiation". This consisted in suspending a radiometer with two parallel fibres and subjecting it to a light source. If external radiant light caused the repulsion then, because of the tiny amount of friction in the glass vessel, the whole instrument would turn in the same direction as the vanes. However if the forces were produced within the instrument, then the instrument would rotate in the opposite direction of the vanes in accordance with Newton's third law of motion. The latter was observed and Schuster concluded that: "The motion in the light-mill is wholly due to the forces acting between the revolving mill and

[67] See Jan GOLINSKI, *Making Natural Knowledge: Constructivism and the History of Science*. Cambridge: Cambridge University Press 1998, p. 140, definition of "black-boxing".
[68] William CROOKES, "On Repulsion Resulting from Radiation. Parts III. & IV." *Philosophical Transactions of the Royal Society of London*, vol. 166, 1876, p. 339 (325–376).
[69] Osborne REYNOLDS, "On the Forces Caused by the Communication of Heat between a Surface and a Gas; And on a New Photometer." *Philosophical Transactions of the Royal Society of London*, vol. 166, 1876, p. 726 (725–735).

its enclosure."[70] Based on the experiment, Reynolds proceeded with calculations that led to the explanation commonly held to this day.[71] His notion of "Thermal Transpiration" and Maxwell's development on that theory eventually explained the radiometer effect as a result of the difference in temperature between the two sides of the vane causing gas molecules at the edge to slide in such a way as to cause tangential stress on the vanes' surface and thereby produce motion.[72]

Consequent theoretical researches on the behaviour of particles and on the properties of rarefied gas by all involved led to the progressive development of a new molecular kinetic theory of gas, and pushed the radiometer away from the centre of attention as it became reduced to merely a context amongst others in which to test the new theory. By 1880, apart from a few sparse speculations, scientists seemed no longer concerned with the radiometer itself, their attention now directed to the phenomena in rarefied gases that it had contributed to enlighten. [73]

Thingness: materials and technologies

While such an unpacking of black-boxes is now common practice in approaches to the history of science and technology, the plaything methodology adds a dimension that seems to be left out by such historiographies: they seem to overlook what the thing itself does outside of socio-political and scientific discourses, to leave out what the instrument's "thingness", the materials and technologies at work in it, afford to perception, action and understanding.

[70] This was later regarded as the "crucial experiment" on the radiometer. Arthur SCHUSTER, "On the Nature of the Force Producing the Motion of a Body Exposed to Rays of Heat and Light." *Philosophical Transactions of the Royal Society of London*, vol. 166, 1876, p. 718 (715–724).

[71] REYNOLDS, "On the Forces," p. 730.

[72] Osborne REYNOLDS, "On Certain Dimensional Properties of Matter in the Gaseous State," Part I-II *Philosophical Transactions of the Royal Society of London*, vol. 170, 1879, pp. 727–845; J. C. MAXWELL, "On Stresses in Rarified Gases Arising from Inequalities of Temperature." *Philosophical Transactions of the Royal Society of London*, vol. 170, 1879, pp. 231–256.

[73] It is worth noting that in 1924, Albert Einstein contributed additional explanation to the radiometer's behaviour that was picked up by M. Knudsen who elaborated on it in 1930. The "Einstein effect" suggested an additional phenomenon at work in the radiometer: that of the excess pressure at the edges of the vane. This would be caused by gas molecules at the edge being held back both by molecules rebounding on the vane one side and, less effectively, by molecules passing the edge to the cooler side.

This attention to technology and materials in play may be the essential aspect that leads a consideration of scientific instruments into the realm of playthings. Scientific instruments are things made with skilful use of techniques and materials (ahead of and informing form), and engagement with them foregrounds the affordances of these in the exploration of the world. Moreover, these affordances, by characterising the looping movement of playthings, are shown to vary over time: what particular materials and technologies offer to perception, action and understanding evolves with respect to context, circumstance and perceiver/actor/interpreter. I use the expression "historical affordance" to refer to this notion which is the main argument for looking at the instruments of science and technology as playthings.

Historical affordance

Gibson's theory of affordance gives leeway for a variation in or evolution of the affordance of an environment or a thing, because the ecological environment, as he presents it, is a blend of permanence and change, what he calls "discontinuous change" rather than "transformation" in order to set variance and invariance as reciprocals in describing the stable and changing relationships between self and world. Affordances, he tells us, are specified in the relative invariants over transformations, and involve a reciprocal process of attunement (as in active and progressive adjustment and equilibration towards harmony) between being and environment ("resonating" to one another), a dynamic reciprocity. Since relative ecological constants and affordances that appear to have the quality of stability and permanence persist to the degree to which these constants persist, the invariance of an affordance is just a matter of differing time scales: what seems stable is just in a different regime of duration, it endures. Affordances, then, are always (semi-cyclically) historical. This "historical affordance" of things that changes over time is the principal notion that this methodology aims to tease out.

By regarding scientific artefacts as playthings, the range of "play" in their affordance is brought to the fore, and these variations in and evolution of their affordances call for an historical approach to register them. A historical account can take into consideration the mobility and transformability of things while keeping the memory of their past affordances and anticipating future ones, it can show that change is occurring yet in a continuous subsisting thing. Just as borrowed or adapted terms conserve their prior layers of meaning, so artefacts retain a memory of their past affordances; and just as

terms offer potential poetic uses inspired by earlier ones, so objects suggest further ways of deploying them that extend previous uses and practices. There is always time in things: they are chronic (rather than temporal) because they recurrently change and sometimes disobey what we think is characteristic of them. In order to take this into account, the methodology set out here approaches objects in a historical way, which is not to say that it does so chronologically: history is not considered as a linear progression and no such thing as precedence or a "more real" reality is posited. Like the looping structure of play, it is viewed as a semi-cyclical spatial movement rather than as a matter of succession: sometimes what happens latest in an object's career is what seems more "primary" at the time and place of writing. No such thing as a "more primary" quality or characteristic or role of a thing is therefore posited or assumed, except in relation to a particular perspective/context/etc. Although I will resort to using it in the text, this explains why "declination" is not quite the adequate term to describe what might appear to be the "other" lives of things: it implies that there is a "real" life and an order of precedence, whereas the plaything methodology considers that all manifestations of an object are valid.

By adopting this historiography, the varying affordances of artefacts are brought forward, and any suggestion of pattern or objectivity is understood as the result of a regular recurrence or of repeatedly instantiated sets of relations. The unfixity, uncontainability and irreducibility of the artefacts considered thus foregrounded render them ideal for a "philosophical" and "elastic" understanding of things that is also involved in a thought about its own processes. Instead of stable information and definition, scientific instruments regarded as playthings offer a lot of scope for "tuning in" to them as thinking things, with sometimes the reward of rare moments of "being in tune" with them: they become, in other words, ideal philosophical toys.

The radiometer's historical affordances

The notion of historical affordance as I've described it above brings attention to the different materials and technologies that compose the device as histories, first of each constitutive part separately and then of their particular arrangement and relationships within it.

In the case of the radiometer, this involves looking at the cultural history of glass, its affordance as a material and process, and the problems that its transparency and transitivity generate. Literary scholar Isobel Armstrong reminds us that 19th century glass was blown by artisans, which means that

in using it "you literally looked through, and by means of, somebody else's breath."[74] She explains how as a consequence of its availability and ubiquity in the mid 1800s it came to participate in the formation of consciousness itself and suggests that the epistemological questions raised by glass at the time were about mediation, transitivity and their implications. The dialectic of glass, at once letting through and blocking, or selectively doing one or the other, generated, she writes, "different kinds of epistemological confusion out of the very lucidity of glass."[75] Transparency and mediation are at the heart of this confusion: "Just as the artisan's breath was invisible, so also was the fact of mediation, as the invisible shaped experience."[76]

Attention to glass as substance and process allows us to problematise the radiometer's glass enclosure in laboratory practice in terms of surfaces, membranes and boundaries. It also brings attention to technologies of containment, and leads us to the next material constitutive of the device: the vacuum (though later understood as partial) that it is a necessary vessel for.

The radiometer was for the scientist James Clerk Maxwell first and foremost a device that allowed, by means of a glass globe both impermeable and see-through, for the sealing and observation of vacuum, or at least of a condition or medium "much nearer to nothing" than had previously been achieved.[77]

Interrogating vacuum, which only became an experimental object that could be made and manipulated in the late seventeenth century, opens up discussions about the hypothesised subtle medium called "ether" and its use as a trope for natural philosophical investigations. It crucially allows us to look into its affordance to Crookes' spiritualist investigations: this attenuated environment held for him the possibility of revealing the effects of parapsychological transmissions, its conductive capability mirroring that of the sensitive mediums of nineteenth century séances – the radiometer, for Crookes, could render spiritual energy phenomenal.

[74] Isobel ARMSTRONG, "Technology and Text: Glass Consciousness and Nineteenth-Century Culture." In: FLINT, K. – MORPHY, H. (eds.), *Culture, Landscape and Environment: The Linacre Lectures 1997.* Oxford: Oxford University Press 2000, p. 149 (149–175). See also Isobel ARMSTRONG, *Victorian Glassworlds: Glass Culture and the Imagination*. Oxford: Oxford University Press 2008.
[75] *Ibid*., p. 149.
[76] *Ibid*.
[77] Letter from Maxwell to Robert Cay, 15 May 1876, quoted in S. G. BRUSH and C. W. F. EVERITT, "Maxwell, Osborne Reynolds, and the Radiometer." In: MC CORMMACH, R. (ed.), *Historical Studies in the Physical Sciences, Volume 1*. Philadelphia: University of Pennsylvania Press 1969, p. 112.

It can then be studied as a device for explicating an environment where different laws of nature operate, its magical potential heightened by the suggestion of perpetual movement in the rotation of its vanes.

Artistic declinations

Furthermore, the plaything methodology allows us to look at artistic practices that put the instrument to use, bringing alternative affordances to view and suggesting future ones. Various artworks can be considered as material "declinations" of an instrument in a chain of connection that links objects to one another.[78] An attention to artworks is particularly fruitful in uncovering an object's affordances outside of its designated function because of the way in which artists put things maximally to play in their investigations, processes and productions. Three brief examples demonstrate how this is the case with the radiometer.

The artist Francis Picabia's 1913 watercolour *Mechanical Expression Seen Through Our Own Mechanical Expression* shows an abstracted radiometer that he uses to represents the dancer Stacia Napierkowska.[79] The analogy puts forward the empathetic affordance of the radiometer's performance, inversing the usual trope in his title so that it is human movement that promises to reveal the inner working of the device.

In *Northern Lights*, the novelist Philip Pullman alludes to the radiometer when describing the magical effect of a scientific instrument:

> Then it became clear: a little thing like a weathervane, with four sails black on one side and white on the other, began to whirl around as the light struck it. It illustrated a moral lesson, the Intercessor explained, for the black of ignorance fled from the light, whereas the wisdom of white rushed to embrace it.[80]

Pullman's account puts forward the device's resonance as a holy object and sheds light both on Crookes' adoption of it as a symbol of his epistemic virtue and on the reasons for which it seems to promise a link between the physical and the metaphysical.

[78] The word "declination" is taken from Christopher PINNEY, "Things Happen: Or, From Which Moment Does That Object Come?" In: MILLER, D. (ed.), *Materiality*. Durham – London: Duke University Press 2005 (256–272). In this article he suggests that networks of objects might offer an alternative method of engaging with things.
[79] Francis PICABIA, *Mechanical Expression Seen through Our Own Mechanical Expression*, watercolour and pencil on paper, 1913. New York, Collection Lydia Malbin.
[80] Philip PULLMAN, *Northern Lights*. London: Scholastic 1995, p. 149.

More recently, artist Luke Jerram's chandeliers, made of hundreds of radiometers (665 for a 5m tall chandelier), multiply the device's aesthetic effect in a spectacular demonstration of its flickering play with light, bring forward the sensitivity of its responsiveness to environmental light and heat and seem to point to an infinity of atmospheric enclosures each contained in an ever larger one.[81]

While I cannot expand on these examples within the scope of this article, these brief sketches demonstrate how productive the study of artistic declinations of instruments can be. Once regarded as playthings, they are found to share the aesthetic inspiration of artworks that put them to play.

I have elaborated in this article a phenomenological/ecological understanding of the plaything in order to argue that considering scientific instruments as playthings is a generative methodology that restores their mobility and inherent transformability, takes into account the skill required in making them as well as their historical affordances and allows for their consideration alongside objects from different fields with which they resonate. I hope that in doing so I have made a convincing case for reviving the category of philosophical toy in studies of science and technology.

[81] Luke JERRAM, *Chandeliers* (undated). See project page on the artist's website available at: <http://www.lukejerram.com/projects/chandeliers> [cit. 13. 4. 2013].