Chapter 2
Affect Channel Model of Evaluation in the Context of Digital Games

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Abstract Psychological emotion theories are underused in digital game research, possibly because they are divided into several competing camps and because they do not provide a framework easily applied to a context of digital games. I present a first step towards an integration of the camps, especially by combining Panksepp's view on primary processes, Scherer's component process model, and Cacioppo and others' evaluative space model. While specifying the different parts of the affect channel model of evaluation, I discuss how they are likely related to common game-related phenomena.

Introduction

Despite the wide recognition of the importance of emotions for game experience, the knowledge provided by **psychological emotion theories** has been little utilized in game experience research. One reason, no doubt, is the fragmented situation of the emotion theories: after a century of emotion research, different models attempting to explain how emotions work are counted in dozens, if not hundreds, and the researchers still cannot agree on what an emotion is (see the two Special sections on the topic that do not reach a conclusion, in the journal Emotion Review: [15, 37]). With the theories also often focusing on very specific features, they are also difficult to apply to a specialized field with a complex and still relatively poorly understood stimuli, such as digital games. As a result, most game researchers, who come from a wide range of backgrounds, have developed their own ideas on how emotions might contribute to the game experience that have little or no connection to the literature of emotion theories (for a rare exception, see [4, 20]). Mostly, only psychophysiological game research has been referring to emotion theories as a background (e.g., [25, 26, 34]; see [17], for a review of psychophysiological game studies).

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Although individual theories do not give much answers, looking at them closely results in finding that many of them are not irreconcilable. In this chapter, I describe my interpretation of combining several emotion theories, and my suggestion how the combination can be used to explain phenomena related to game experience. Acknowledging the irony [28], I present my own model, the Affect Channel Model of Evaluation (ACME).

Background

While the theorists seem to be more interested in developing their theories in a rather limited area, the connections between different emotion theories are actually quite numerous when one knows where to look for them. Without the space to go into specifics here, in short, Panksepp's primary processes and LeDoux's survival circuits seem basically different descriptions of the same neural patterns (e.g., [21, 32]). Most emotion theories agree on some kind of appraisals that, in turn, have commonalities with the neuroscientific evidence (e.g., [5, 40]). In addition to obvious connection between core affect [35] and evaluative space (originally by [6]; see [29], for the current situation), the latter idea also overlaps LeDoux's "global organismic states" [21]. Thus, ACME is my synthesis: especially Panksepp's account on primary processes that form the neuroscientific base of specialized neural circuits adapted to specific evolutionary challenges; Scherer's Component Process Model (CPM) that provides the organization of laying the primary processes/survival circuits in a temporal order according to appraisals that activate them; and Cacioppo and others' Evaluative Space Model (ESM) that describes the global motivational state of the system that affects and is affected by appraisals and primary processes. The model is further influenced by Russell's [36] constructionist views that emphasize domain-generality[1] and higher conceptualizing processes that happen after the initial evaluations but that affect their next iterations by the various feedback loops.

ACME presents an interpretation of the automatic **evaluations** (or appraisals[2]) and the process cascades they activate non-consciously within about a second from the perceived change (cf. metaphorical "System 1" by [16]). Particularly, I attempt to find the time frame in which the evaluations might be processed, tied to the type of processing required for the evaluation to be possible (the processing levels inspired by four levels by [39]). I conceptualize the evaluations and the resulting neural activation spreading by describing **affect channels**, the evolution's way of organizing the contradictory action tendencies into coherent, prioritized response

[1]The "domain-generality" does not imply that the functions are not specialized—only that the domain of specialization is not "emotion" (cf. [19], Chapter 2).

[2]I prefer 'evaluation' over 'appraisal', because the latter is a strongly loaded term specifically related to appraisal theories and the theoretical constraints related to that literature.

modes. The present model is a gross simplification[3] of the intricate details provided by the abovementioned theorists, but it lays out the general structure of the system that produces affective responses.

As a clarification, *ACME is not primarily a model of emotions*, *but of motivational evaluations*. The name of the model reflects that: instead of referring to emotions, the 'affect' of affect channels refers to any feelings that move us (cf. [32]). What we call emotions simply happen to be among the most recognizable outputs of the evaluation processes.

Why not emotions? Any model of mind must be subordinate to the physical reality (described by neuroscience) and an evolutionary explanation of how it has evolved (e.g., [43]). There is no reason to posit the existence of a unitary "emotional system"—instead, evolution favored development that ended up, one by one, in a collection of processes that do their part in discerning certain survival- and procreation-relevant stimuli (evaluation) and preparing the organism for suitable action (motivation). Intertwined with other functions like perception, attention, memory, and so on, this covers all kinds of affective responses—such as pain, hunger, balance—without limiting to 'emotions' alone. I share the doubt Russell voiced [36], whether the term 'emotion' has any scientific value, with its referents so nebulous and arbitrary; like LeDoux [22], I prefer to use the word like a layperson would, as a non-scientific descriptor referring to those subjective feelings we consider emotional, including the landscape of feelings related to the game experience.

Model Details

Building Blocks

ACME posits that the evaluation system consists of the following parts: the low-level modules, affect channels, and the global evaluative state. In addition, I have organized the model according to two criteria: processing levels and biological priority order (Fig. 2.1).

The low-level **modules**[4] are functions that most likely are actual physical structures that can be—and in some cases already have been (e.g., so-called fear

[3]I have ignored, among many details, the whole system of homeostatic functions (pain, hunger, thirst, uncomfortable temperature, fatigue) which I contend should be recognized as an affect channel on their own right (cf. [31]).

[4]Following Kurzban [19], by "module" I mean "information-processing mechanism specialized to perform a particular function"—not the strong Fodorian module. Although I assume that the neural substrates of the modules can be found in the brain (see below), I do not assume that different modules are necessarily distinct from each other on the neural level. Therefore, I use expressions like "a module x is based on module y", meaning that the neurons that carry out the functions are largely the same, but because the modules are related to the function, the modules may be different.

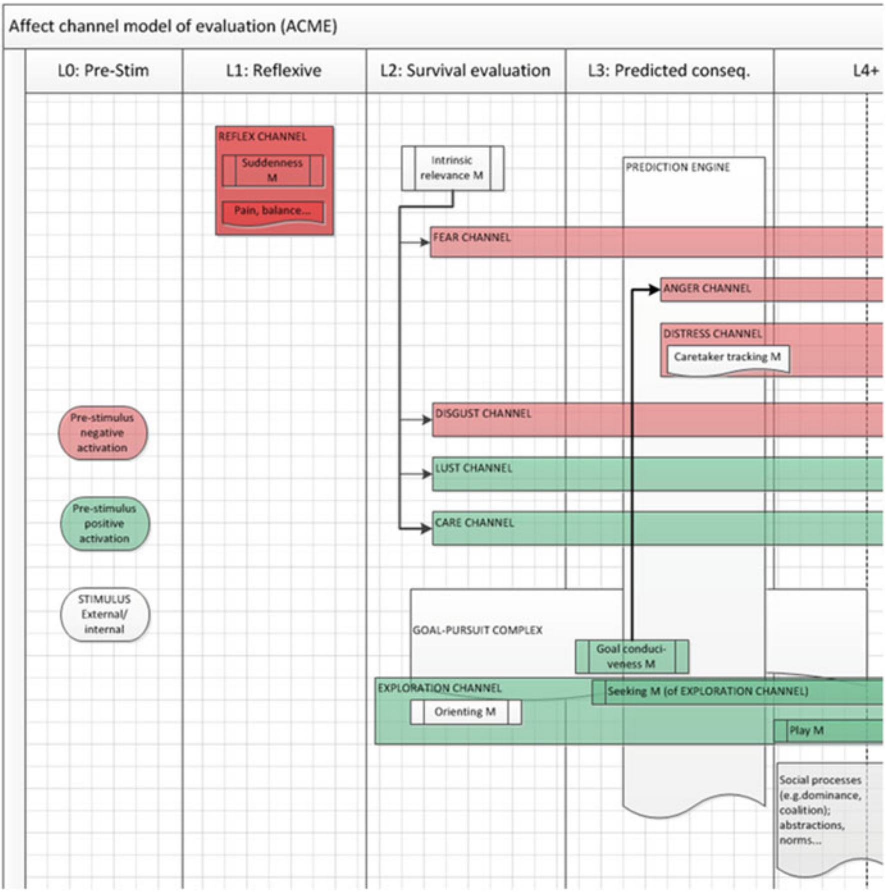

Fig. 2.1 Affect channel model of evaluation. Ovals in L0 represent baseline effects. *Boxes* represent affect channels or modules; *red color* indicates a primarily negative influence on GMS, *green* a primarily positive influence. All channels are activated by evaluative modules, but only the known modules are shown. *Wavy boxes* indicate that something like that should exist, but the details for including them in the model are unclear

circuit: [23])—found in the brain. I sometimes discuss the two functions of these modules, the evaluator and the mobilizer, as if they were separate, because they are based on ideas from different theories (appraisals and primary processes, respectively). On the neural level, however, they are most probably simply two functions of the same module, as modules are evolved as adaptations for a particular function, and it does not seem likely that these functions would have evolved separately.

The evaluators, based on stimulus evaluation checks by Scherer [39, 40], process the sensory information[5] according to a particular adaptively relevant question, regardless of whether it originates from the sensory organs or is internally created by recall or imagination; in a sense, their output is an answer to one question (such as "is this stimulus new?"). Evaluators determine which mobilizer should be started, if any, from an evolutionarily predetermined set. When activated, the mobilizers, based on primary processes [32] and survival circuits [21], launch (again, evolutionarily predetermined) large-scale activation changes both in the brain and in the autonomic and somatic nervous systems (ANS and SoNS), resulting—if not inhibited by other processes—in observable changes in emotion components. I list modules for only some channels mainly following the appraisal theories, but obviously all channels have some kind of modules for evaluating the stimulus—we just lack the empirical details.

The **global motivational state** (**GMS**), based on the evaluative space model [29], represents the extent the organism is in positive (approach) and/or negative (avoid) motivational state. The GMS is changed by most mobilizers, and it affects all neural modules, positivity inhibiting negative evaluations and activation spread while facilitating positive evaluations and activation, and negativity influencing evaluations and activation in the opposite manner (cf. mood congruency; [35], p. 156). Although the effects of an evaluative space are well supported by evidence (e.g., [30]), it is unclear how the GMS is manifested on the physical level (i.e. where is the information on positivity and negativity stored?). For the purposes of this chapter, the evidence supports the treatment of the GMS as an abstract "state" omnipresent for neural modules.

Affect channels, therefore, are the specific patterns of neural modules that follow a particular adaptive function in order to produce suitable behavior. On the level of affect channels I also separately postulate two important **general-purpose functions** (goal-pursuit complex and prediction engine) that are not primarily evolved to produce behavior but to help affect channels to do their jobs. I have inferred their existence by the functions required by the model, but their neuroscientific basis is currently unclear. The individual affect channels are briefly described after explaining how the model is organized.

[5]Note that by "stimulus" I do not mean, for example, a single seen object, as the visual system makes the distinction between objects relatively late ([10], Chapter 5). Instead, I mean the information that reaches an evaluator after being processed by different perception modules into some format that it can evaluate. That is, like the perception modules, the evaluators focus on very specific features of the perceptual information, from a simple feature like darkness, to a highly processed understanding of the environment and context. This also means that while I assume an external stimulus (such as a digital game), the model does not ignore self-caused (imagined or recalled) stimuli, that are treated no different from the external stimuli when they are fed to the evaluators. This is supported by the vast evidence that imagined situations lead to same kind of physical changes in the brain than external stimuli (e.g., [13]).

Organization

To promote adaptive behavior despite conflicting motivations between the different mobilizers, the affect channels must have a biologically wired **priority order**. This is the sensitivity to activation of the channels more relevant for imminent survival, compared to those less relevant, resulting in an ability to easily override motivations of less pressing concern. The priority order does not imply fixedness. Rather, it is the relative strength between the channels—a channel higher in the order needs less activation to override a channel of lower priority. Conversely, a sufficiently strong activation on a lower-priority channel may still result in the individual engaging in behavior where the mild concerns for survival are temporarily suppressed. The GMS further tilts the table so that certain evaluations and output activations are more likely than others, making overriding easier (negative activation) or more difficult (positive activation).

To provide further structure between the channels and their contents, ACME is organized according to the **processing levels** respective to the complexity each neural module requires. (These levels are meant as a tool for understanding the relationships, not as descriptions of natural categories.) Simultaneously, the levels roughly describe the relative time frame in which its processes finish[6]—although likely all survival-related processes launch as early as possible, the more complex processing goes through more complex neural networks and therefore takes more time. The levels are: pre-stimulus level (L0), reflexes (L1), survival evaluation (L2), evaluation of predicted consequences (L3), and complex, conceptual evaluation (L4+) processes. As the L0 implies, the time frame is relative to a moment when a new stimulus is detected. Although Cunningham and others' [9] critique—that there is no "time zero" because all processes are running all the time and the previous activity acts as a powerful biasing factor for further processing—is valid, the greatest changes occur when a new stimulus is detected, making it the best reference point.

Like the whole CNS, the modules are connected in a heterarchical way [29], many of them running in parallel and some earlier processes serving as the necessary activators of some later, but processes also being activated, facilitated, and inhibited by processes from higher levels. For example, most of the early processes, although powerful in directing the organism for action, can be inhibited by conscious effort. The processes are recursive and are updated constantly, but I mostly discuss only the first iterations.

Further, it is important that while the late processes may affect the next iterations of the early processes by inhibiting (or facilitating) the outputs of the mobilizers, the evaluators activating the mobilizers is involuntary (further supporting the assumption that actually the two are two parts of the same module). This is apparent in situations like flinching when a sudden movement is detected near the head, feeling scared when alone in the dark, or feeling lust in presence of strong sexual

[6] I also note that the levels seem to correspond roughly to the (probable) evolutionary and developmental order of appearance, but this is not the main purpose of the levels.

cues. If the evaluation is made, some kind of response (although it can be dampened) is inevitable. The only way to avoid the response completely is to change the situation so that the evaluation is never made.

Finally, conscious awareness is not assumed to occur clearly at one point in this time-frame—instead, I believe it is gradually constructed from several different processes within a longer time window, and it only gains access to a small part of information from the processes described here (cf. [19]).

Affect Channels

Some of the affect channels can be further labeled based on their urgency related to survival. Those that handle evaluations requiring urgent responding are higher in priority than those that evaluate stimuli with non-urgent responses. Urgency does not equate priority, however: for example, the Anger channel is not evolved for survival-urgent situations, but its priority is high.

The evolutionary principle of conserving resources dictates that if it is not necessary to act, the organism is better off resting than spending valuable resources. On the other hand, when the resources are not scarce so that they should be saved only for the necessities, it is useful that the organism ensures the future survival by securing more resources and learning the environment. The **Exploration channel** is the implementation of this function. Its activation is of the lowest priority: it directs behavior most when nothing is evaluated to be threatening the organism, no particular goals are pursued, and the resource-gathering modules are inactive. When nothing more pressing is requiring attention, it drives the organism to explore and find relevant resources. Originally that has meant food, water, shelter, and mate, but other adaptations have expanded the domain of this channel to social and abstract resources (such as knowledge) as well.

Although the **Goal-pursuit complex**, on the neural level, is likely an extension for the Exploration channel added with currently unknown other components, I discuss it separately because it clearly forms a general-purpose function. It gives the other channels the tools to pursue specific goals, rewarding the seeking—not only of new things, but of anticipated things. The other channels likely also have separately their own each reward mechanisms, producing positive feelings in the end of their respective action mode (sexual gratification is the clearest example, but, e.g., the removal of anger-inducing obstruction is also satisfying).

The non-urgent survival channels are essential for survival, but not so urgent that something must be done about them immediately. After a resource is found, it should be consumed. In the case of food and water this is simple: separate consumption modules (not presented in ACME) kick in that reward drinking and eating. In case of mating the process is more complex, and requires a broader response pattern to ready the body and to signal that readiness, implemented by the **Lust channel**. Because the channels are evolutionarily adapted, the organisms do not only secure their own well-being, but also that of their offspring. The

Care channel works in tight interaction with the Exploration channel, promoting resource-securing behavior for the offspring as well, as well as looking after and keeping the young themselves in safety.

The activation of the urgent survival channels requires immediate action. The **Disgust channel** is the least pressing, driving the organism to avoid potential sources of unhealthiness—carcasses, bodily wastes, and spoiled foodstuffs, but also outsiders that carry a greater risk of disease for the whole community [14]. The **Distress channel**, especially active in the young and the nurturing mothers, keeps track of the mother/offspring and promotes, again in tight interaction with the Goal-pursuit complex and the Exploration channel, behavior to reunite lost loved ones. The **Fear channel** reacts to the myriad signals of imminent threat in the environment and has an elaborate array of evaluation and mobilization circuits at its disposal to advance survival.

The **Anger channel** is probably located between Distress and Fear in respect to priority, although its urgency for survival is not typically high. This channel responds when the goals set for the Exploration channel to pursue are obstructed, mobilizing resources to remove the obstruction by force.

Finally, the **Reflex channel** responds immediately and automatically to direct damage, or the threat of it, by moving the body out from the immediate danger. Its priority and urgency are the highest, but the responses are also so quick that it does not hinder other survival channels activation much.

The Model

Pre-stimulus Level (L0)

The **pre-stimulus level** describes the processes that can be assumed to be running in the absence of any particular stimulus that would have been evaluated to require a response. This level does not imply anything about the time frame of its processes, since they are not launched by detecting a new stimulus.

Exploration Channel In absence of other activation (and of scarcity), the **seeking module** constantly makes the organism look for something rewarding, instead of doing something that does not give immediate rewards (i.e., procrastinating, channel surfing with TV, constantly checking social media). In the brain, this is driven by the dopamine system which responds to novel, attention-grabbing events, but stops responding when the stimulus grows too predictable ([21, 32]; see also: positivity offset, in [29]). The module evaluates the novelty of the stimulus (cf. novelty check in [40]), and directs attention to those evaluated new while increasing action readiness (arousal). Interacting with higher processes (see L4+, below), it also evaluates stimuli that carry the possibility of finding something new—process that is expressed as mild interest. In games, this results in the eponymous exploration behavior in sandbox worlds (is there something interesting behind those hills?)

and continuous completion of easy tasks when it carries the promise of a reward (clicking away in Candy Crush, grinding in World of Warcraft, or the "one more turn" effect in Civilization and its kin; see [18], for a similar idea of play as exploration). The activity itself is not that interesting and the rewards are not actually that satisfying when they are obtained, but the design that has always something new behind the corner activates the seeking module which continues until some other process stops it—or when the activity grows so predictable that it does not produce new rewards anymore.

Other Channels Of course, the "absence of other activation" is not a trivial criterion. Evolutionarily, seeking new resources is useful only when the imminent survival is not threatened. Contemporary humans rarely have to be afraid of predators, but hunger and very hot weather turn the seeking module into finding relief instead of exploration. Similarly, stress, worry, and irritation prevent the seeking module to kick in. In depression, nothing feels like anything anymore—the seeking module does not work, does not give reward for finding new things, leading to apathy. Positive feelings can prevent exploration as well: the activation of Lust channel sets the goal to sexual gratification, foregoing leisurely exploration in order to seek sex ([32], Chapter 3)

Reflexes (L1)

The first level describes processes that occur reflexively: activation of SoNS is launched immediately when a module calls for it, directly from the subcortical brain regions without waiting for further higher-order processing. This may happen before 100 ms from the stimulus onset.

Reflex Channel The very rudimentary features of the stimulus are evaluated by the **suddenness module** (cf. suddenness subcheck in [39]), detecting sudden loud and abrupt sound or quick and large movement in the visual field. This activates the startle response, resulting in an increased alertness (guiding attention to scan the perimeter instead of focusing intensely to one target) and elevated action readiness (heart pounding and palms sweating; increased GMS negativity) in response to moderate activation, and in addition to these, dodging and shielding movements when the activation is high. All this happens nonconsciously, and the information about their occurrence reaches the consciousness only afterwards.

The suddenness evaluation is exacerbated by pre-existing negative and slightly inhibited by positive GMS activation. The higher-order processes of anticipation also inhibit the response, to an extent, as the organism's understanding of the environment creates expectations: if the organism readily expects a loud sudden noise (e.g., a bang of the player's own weapon or when a previously detected monster crashes through the window), the startle response will not be activated by it. However, this only applies to the expected stimuli (i.e., if a bang was expected, a sudden “boo!” from a person behind the player still gives the response).

Pain and balance reflexes can probably be included in the Reflex channel as well, but they do not seem relevant in gaming context.

Survival Evaluation (L2)

The second level evaluations are processed a bit further, **pattern-matching** the stimulus information to genetically inherited patterns, recently detected stimuli, or the current low-level concerns set by higher processes. The patterns are still relatively simple because the responses need to occur quickly, around 100–200 ms from the stimulus onset [12]: they are adaptations that protect from immediate threats relevant to our hunter-gatherer ancestors.

Survival Channels The main survival evaluation is common to most survival channels. The **intrinsic relevance module** compares the current stimulus features to evolutionarily relevant patterns that signal relevance to survival [40]. Darkness and stimuli that resemble spiders, snakes, or angry and violent faces activate the Fear channel, and stimuli resembling human waste or other disease carriers activate the Disgust channel, both resulting in withdrawal motivation and higher action readiness. The detection of sexual cues more the Lust channel, and detection of nurturance cues the Care channel. When the GMS is already negatively activated, the module evaluates things easier as threatening, and when positively, the sexual and nurturance cues are evaluated as stronger and more likely.

In games, the primal fear cues, and to some extent disgust cues as well, are commonly used in environment and enemy design, because they fire up arousal and activate suitable threat-related associations, creating a suspenseful mood, and they mobilize action that lead to gratification when the goal has been reached (i.e., removal of threatening entity). While in a virtual world the Lust channel cannot (at least currently) reach its goal, sexual cues are often used for their arousal-inducing effects (although mostly for heterosexual males). In games that require looking after some characters, the game designers often use nurturance cues such as big eyes and soft and round facial features resembling infants, because they activate warm and fuzzy feelings and care tendencies—if you go “aww” upon seeing something, the intrinsic relevance module has activated the Care channel.

Exploration Channel When the stimulus is not intense enough to elicit a startle reaction but is evaluated as novel, the **orienting module** elicits an orienting response. It probably uses at least partly the same circuitries as the more complex seeking module, reacting to novelty, and might be linked to the intrinsic relevance module as well. Orienting response is a basic tool in the human attention system but does not have much significance for games per se.

In games, all goal-directed action involves assessing whether a particular stimulus is relevant for the current goals or not. According to the empirical evidence (the "concern pertinence" check in [12]), the early modules of the **Goal-pursuit complex** evaluate the stimulus for goal relevance in this time window. Considering that the other evaluations on this level probably only do simple pattern-matching, the processing here are not likely to be much more complicated. As the processing behind goal-pursuit in general however are necessarily more complicated than that (evaluating, e.g., whether a certain change in the zerg movement patterns in StarCraft 2 requires a response or not in respect to the player's goals), the early modules are likely provided preprocessed patterns to match (e.g., react when those mutalisks start moving).

Evaluation of Predicted Consequences (L3)

The next level of processing complexity goes beyond simple pattern-matching to involve associative memory, and specifically the other general-purpose function: the **Prediction engine**. In brief, I use the term to refer to the function where the stimulus is associated with similar occurrences in memory to see what happened on those previous situations, and therefore to predict what might happen now. The initial, immediate prediction is the most available situation, which might or might not be the most likely one (depending on how the neural weights have been arranged earlier).

The process is still very much automatic and nonconscious—relevant processes occurring around 300–600 ms[7] [11]—and it probably uses innate logical structures that, for instance, deduce causality from sequential events (named "causal attribution" or "agency" by appraisal theorists: [41]; attribution also discussed by [35]), as famously discussed by David Hume. Until the capability to attribute causality to perceived agents or to predict consequences of events, the stimuli are without any social meaning, and for example the fear response cannot be more complex than to turn around and run. With this first bit of contextual information, much better goals can be set for the Goal-pursuit complex to seek.

Goal-Pursuit Complex and Anger Channel The most obvious result of the interaction with Prediction engine is the evaluation of obstruction or furthering the current goals by the **goal conduciveness module** (or appraisal: [38]). If the

[7]How can the elite Counter-Strike players play this extremely fast-paced game, if the simple evaluation of the consequences of an action is supposed to take half a second? The experiments about the timings have been carried out with abstract tasks that people have no previous experience with. When a familiar environment is navigated, the typical situations and their consequences are already associated to their evaluations and behavioral responses, allowing quick responding by automated motor patterns that border reflexes in extreme cases. Instead of absolute timings, the levels are meant to indicate the relative processing speeds of different processing types—the milliseconds are secondary.

goal conduciveness module evaluates the stimulus event to further the goals, it increases positive GMS. However, obstruction of goals activates the Anger channel, mobilizing bodily resources for removing the obstruction—and ultimately leading to the subjective feeling, the distinctive flare of anger or frustration. In gaming, this evaluation occurs, for instance, when the computer freezes just as you were doing something, or when other people get in your way.

Distress Channel When the track of the caretaker or offspring (or probably any other strongly bonded individual) is lost by a caretaker tracking module of some kind (appraisal theories do not provide a clear indication of what this might be), the Distress channel is activated ([32], Chapter 9), causing social signaling for needed help and (for the caretaker) mobilizing resources for getting the offspring back by force if necessary. If a permanent or long-time separation is predicted, the behavioral components are inhibited but the activation still remains, manifesting as sadness and grief. Games are almost never able to create enough bonding to virtual characters to make use of this channel, although exceptions have recently appeared (e.g., Telltale's Walking Dead).

Other channels The seeking module on the Exploration channel, enabled by the Prediction engine, was already described in L0. The predictions also affect the activation on other channels. As mentioned, with better understanding of the context, the Fear channel and the Goal-pursuit complex can now set more adaptive goals, but similarly, the responses by Disgust, Lust, and Care channels are modified by the new information. For example, it is possible that the inhibition of primal behavior occurs at this level: you don't habitually avoid the plastic fake vomit you find in your prank box, or you simply nod while listening to the extremely attractive person next to you, because the module in your head predicts that those approaches do not result in undesired consequences. When the activation is not extremely strong (or the learned regulation mechanisms particularly weak), adult humans can and do inhibit most of their responses that the evaluative system promotes. In a gaming context, inhibiting the Fear channel behavioral responses—while still getting the arousal activation from the evaluations—is the basis of the horror games.

Conceptual Evaluations and Further (L4+)

Many emotion theorists say that later in the construction of emotion "conceptualization" and "categorization" occur [2, 36], but unfortunately, there is little empirical information on what the more specific processes are or even what would be their general structure. One step before moving into full-blown abstract thinking is the broader contextualization of stimuli, utilizing more complicated predictions and the comprehension of more complex relationships between different agents, events, situations, objects, and time concepts, while abstractions of these relationships into general rules seem to be another step. However, with this vague understanding it is difficult to identify clear modules or the principles on which we might make distinctions between their processing levels. Scherer (e.g., [40]) and other appraisal theorists, for example, specify norm compatibility as a separate appraisal, but it is not clear what the process actually is (is there one process or many? what kind of requirements they might have?). Most of them are also out of the focus of this paper, so apart from one exception below, I leave the higher processes on levels 4+ untouched.

For the game context, the most interesting module can be inferred from Panksepp's work ([32], Chapter 10): along with the capabilities for understanding social context, the **play module**, strongly based on the seeking module, is enabled. The evolutionary function of the play module is assumed to be a way for the organism to learn physical and social rules and skills[8] (i.e., seeking informational and social resources) by testing them and their limits in a safe way. The example of this is a rough-and-tumble play that occurs with all mammals, where the young test the relationships they have with each other and with adults (e.g., an adult or a pup that have been established as stronger will pretend losing to a weaker one; [32], Chapter 10). This kind of a second-order seeking is only possible when the young begin to understand the social world as a new environment to explore: enough to being able to predict it somewhat (seeking does not activate in the first place until the prediction engine can predict finding something), but not too much (activation of the seeking module stops when nothing new can be found). However, the play of this kind is still first and foremost *activity*—the behavior patterns the module produces.

Interactions between the play module and other processes expand the variety of rules and skills that are explored. For example, interaction between the play module and the Lust affect channel has an important role in finding and courting a mate in many animals, although the complexity of the social world of humans makes it more difficult for us. Competition, in turn, is arguably a result of interaction with the (probably higher-order) processes related to social dominance. With the development of more abstract understanding, humans can extend the exploration to abstract rules and systems as well, especially in sports. Digital games engage (mostly) this kind of exploration with heavily automatized play in eSports, but also with game design/player behavior patterns like leveling up (i.e., finding out new ways to do things) and mastering the behavior of the game (such as movements of the character in the game world; i.e., honing the skills and the predictions like animals in a rough-and-tumble play).

[8]Note that albeit the evolutionary function of the play module is to learn survival-relevant skills and understanding, the modules themselves do not regulate their operation according to whether there is actual use for the skills and understanding in the life in general. Procrastination and diabetes occur for the same reason: the modules behind our behavior have evolved in a much more resource-scarce environment where *too much resources* was never something we needed to adapt to. Play is the same—it was never "meant" to be available as often as it is in the modern world where we don't have to focus on survival all the time. All play the individual had time for in the ancestral past was a bonus.

In humans, a still more complex form of exploration—a third-order seeking following the same principle of "predictable but not too predictable"—can be seen in the what-if, pretend, or role play: the exploration of relationships and social rules *that do not exist* between the players outside the game[9] (as opposed to testing the existing relationships as in second-order seeking). This requires a further capability to understand and imagine counterfactual relationship networks (i.e., fiction) and to accommodate one's own behavior according to them. I assume that pretend play is not a result of a separate adaptive module like play likely is, but instead a product of the interaction between the play module and higher-order processes (that are responsible for, e.g., the theory of mind; [24]) that feed activation to it.

As opposed to second-order seeking, what-if play is more *imagining* than activity: the seeking module can now be activated by (and therefore provides satisfaction for) mental simulation of abstract rules (e.g., chess, Magic: the Gathering), but also fictional scenarios. This is first introduced in activities such as storytelling and children's role play,[10] but occurs later for instance in fan culture, role-playing games, and sexual fantasizing. In game context, it creates an additional layer over games that have a fictional theme (cf. ameritrash vs. eurogame board game designs). A further special mode of what-if play is enabled with higher-order processing of regulating one's own affective responses to a degree by contextualizing the situations that the primal mechanisms in the affect channels evaluate. By contextualizing a situation that activates negative affect channels (Fear, Distress, or Disgust) as safe, the rewards granted by the Exploration channel modules enhanced by increased arousal can be enjoyed (e.g., horror or tragedy; [1, 3]). Many forms of gaming also exhibit this dynamic, such as extreme role-playing [27]. Of digital games, the horror genre is an obvious example.

Final Words

The current model is based on theory reading and simplified considerably. It is not empirically tested yet, although the theories and empirical works it is based on have notable support (see section "Background"). Furthermore, my own expertise is in psychophysiology and emotion psychology, so while neuroscience is an important part of the current work, I concede that I am not an expert of that field. Given time, hopefully the inevitable mistakes and misunderstandings will be corrected. Nevertheless, the core of the model is the integration of evidence and theories created by others, not in the details I have conjectured. With the final note below, I invite critics to expose the mistakes, in order to see whether the core can stand when the details are corrected.

[9]Cf. magic circle: [42].

[10]Not in early pretend play, though: young children apparently mimic the activities, without imagining the mental worlds of mom and dad or police and robber [24].

Most of the engagement, immersion, flow, etc. literature seems to describe something resulting from the Exploration channel and Goal-pursuit complex activation (see [7], for a review; see also [33]). Flow, for example, could be understood as a strong activation and interaction of the seeking/play module and the Goal-pursuit complex, when the activity provides clear and frequent milestones, is automated enough to utilize highly specialized motor patterns, and is challenging enough to keep results unpredictable. In addition to the empirical knowledge on the channels (or rather, the primary processes they are based on; [32]) and the timing of specific evaluations related to them [11, 12], there is practical information about the optimal arrangement of reward frequencies and probabilities, most likely indicating something about the brain processes behind their utilization, to be gained from the player data of contemporary massive games (see e.g., [8]).

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